SILICON CHIP

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- Includes: Electronic black box controller, two stage shock sensor, microwave movement sensor, wiring looms, bonnet pin switch, car charger for the remote controls, extra circuits for fuel and ignition cutout and 2 x code hopping remote control units with a built in torch!
- Spare remote available separately LA-9009 $39.95

LA-9008
WAS $149.00

$129.00 SAVE $20.00

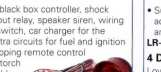
STEELMATE ENTRY LEVEL CAR ALARM WITH VOICE FUNCTION

An affordable car alarm that features voice feedback on alarm status and operational parameters such as open doors etc. Other features include boot release button, valet mode, and emergency override.

- Includes electronic black box controller, shock sensor, ignition cutout relay, speaker siren, wiring looms, bonnet pin switch, car charger for the remote controls, extra circuits for fuel and ignition cutout, 2 x code hopping remote control units with a built in torch
- Spare remote available separately LA-9004 $37.95

LA-9003
WAS $99.00

$79.00 SAVE $20.00



ECONOMY ACTIVE 12" SUBWOOFER

This 12" Subwoofer in a sealed enclosure has a built-in amplifier to match. The unit produces a whopping 75WRMS of astounding bass. Equipped with line level and high level inputs, it also has built-in fuse protection and wired remote level control.

- Bass boost: 12dB
- Gain: 18dB
- Power output: 75WRMS
- Dimensions: 425(W) x 355(H) x 360(D)mm

CS-2269 WAS $99.00

$89.00 SAVE $10.00

Replacement Door Lock Actuators

Master Door Lock Actuator

Door lock actuator for Driver's door. Includes microswitch output to activate power lock relay LR-8818. Supplied with universal mounting hardware. Wiring not included.

LR-8816 WAS $18.95

$12.95 SAVE $6.00

Slave Door Lock Actuator

Door lock actuator used on passenger doors. Supplied with universal mounting hardware. Wiring not included.

LR-8814 WAS $14.95

$9.95 SAVE $5.00

Precision Response 2 x 80WRMS Class AB Amplifier

An affordable 2-channel class AB amplifier. Both channels offer fully variable high and low pass filters, bass boost and pass through RCA pre-outs allowing you to link to additional amplifiers without the additional cost of RCA splitters. Great value first upgrade amplifier!

- Dimensions: 266(L) x 235(W) x 58(D)mm

AA-0450 WAS $149.00

$119.00 SAVE $30.00

Central Locking Deals

2 Door Power Lock Kit

Add the convenience of central locking to your car with this low cost 2 door central locking kit. Durable and easy to install.

- Supplied with 1 master and 1 slave actuator, control relay, hardware and wiring loom.

LR-8810

$29.95

DEAL 1 Buy 1 x LR-8839 & 1 x LR-8810 for $75 Save $24.90

4 Door Power Lock Kit

Low cost 4 door central locking kit. When you unlock the drivers door the other three doors will also unlock. It can be connected to car alarms with a negative triggering locking output, or used with our LR-8839 remote controller for keyless entry.

- Supplied with 1 master and 3 slave actuators, control relay, hardware and wiring loom.

LR-8812

$39.95

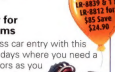
DEAL 2 Buy 1 x LR-8839 & 1 x LR-8812 for $85 Save $24.90

Remote Keyless Entry for Central Locking Systems

Upgrade to a remote keyless car entry with this system. On rainy or windy days where you need a quick entry, unlock your doors as you approach the car. The system is easy to install and comes with two remote key fobs.

LR-8839

$69.95



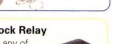
Power Lock Relay

To operate any of the Door Lock Actuators you will need this relay. Suitable for key operation of door locks and remote control operation.

- Negative triggered

LR-8818 WAS $19.95

$14.95 SAVE $5.00



CAR BOOT / HATCH RELEASE

Installs on your boot or hatch lock so that unlocking simply involves pressing a button. Solenoid comes with mounting bracket, wiring loom, dash mount pushbutton switch and installation instructions.

- Solenoid Unit (inc bracket): 95(L) x 43(D) x 58(H)mm
- Switch (on L bracket): 50(H) x 44(W) x 40(D)mm

LR-8834 WAS $39.95

$29.95 SAVE $10.00

NEW Car Audio Accessories

NEW 2011

Line Level Control (Attenuator)

This unit when fitted in a signal line allows you to adjust downwards excessive signal levels. You may have, for example a source from a CD/MP3 player and a tuner. Often one source is too loud (at line level) to the other.

- Stereo
- RCA line sockets in/out
- Dimensions: 60(L) x 55(W) x 37(H)mm

AA-3078

$9.95

Ground Loop Isolator (Stereo) 3.5mm

Used to eliminate ground loop problems in audio installations. The unit has a 3.5mm stereo sockets on both ends. Suitable for use with laptops, MP3 players, iPods® etc.

AA-3086

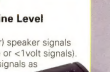
$9.95

Ground Loop Isolator (Stereo) RCA

Used to eliminate ground loop problems (usually manifested as a low hum) in audio connections. Earthing brown ground wires sometimes helps even more.

AA-3084

$9.95



Speaker (High Level) to Line Level Converter

Converts high level (high power) speaker signals back down to low level (i.e. line or <1volt signals). You can then safely use those signals as line inputs to amps without potential damage to amps or other speakers. Features variable attenuators to reduce signal up to 6 times.

- RCA socket out (stereo)
- External dimensions: 90(L) x 35(H) x 57(W)mm

AA-0482

$14.95

10A DC Noise Filter (Improved)

Easy to mount noise filter. Installs with the use of short or long cable ties - no need to drill mounting holes. Reduces noise on the DC power supply to stereos, CB radios etc., better than ever. 10A rated + & - DC lead and earth lead included.

- Dimensions: 90(L) x 60(W) x 33(H)mm

AA-3074

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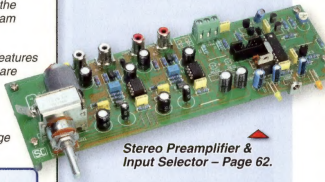

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Publisher's Letter

Mains surge suppressors are not a condition of electronic product warranties

Because my friends and acquaintances know that I am involved with the production of an electronics magazine, they sometimes ask me what is my recommendation of brand and model of TV, video projector, DVD player, audio amplifier, loudspeaker or in fact, just about any electronic or electrical equipment. Now unless one spent all day, every day checking the specs and performance of such equipment, it is just not possible to make specific recommendations; the models seem to change on a daily basis!

On the other hand, if they ask about a particular brand and model, I can perhaps be more helpful and possibly guide them in their purchase by asking what features they need, suggesting that they might look at an alternative approach, such as a high-quality BluRay player instead of a CD player or maybe look at a home-theatre receiver with 5.1 channels rather than a run-of-the-mill stereo amplifier. Sometimes I can refer them to the makers' websites or to government websites for more detailed info they should have before making a decision.

And often I won't hear anything more about it. Sometimes they will tell me what they finally purchased and sometimes the product is far more expensive and up-market than they were originally intending to buy. If they are happy and the product performs as they expect, then all is well.

But then those same people will tell me that they also purchased an extended warranty, an HDMI cable or two and a surge suppressor, with the comment that the surge suppressor was necessary to get the extended warranty. And that's when I feel that the whole process has gone awry.

Now I know that retail is a tough scene and that retailers often seek to up-sell as much as they can, in order to survive. Nor do I disagree with the concept of extended warranties. Given that service charges can be a major proportion of a replacement TV, then an extended warranty can be worthwhile. But the idea that a surge suppressor is required for a warranty to be valid is just false. If any retailer tried that on with me, I would demand to see where it was in the warranty document. Of course, it won't be there.

Nor can there be any suggestion that the manufacturer's warranty specifies the need for a surge suppressor. If that was a condition of the warranty then it would be arguable that the product was not "of merchantable quality". In other words, the product would not work reliably unless it was plugged in via a particular surge suppressor. Well, that's just nonsense. If a product is sold in Australia, then it must work in Australia and cope with the normal range of AC mains voltages present in Australia. To suggest otherwise is an indication that the retailer concerned is selling dodgy products.

In any case, while a surge suppressor may do no harm and may provide some protection against transient voltages on the AC mains supply, it will be no help in the case of a lightning strike. As any appliance serviceman can attest, the most effective way to protect electronic equipment from lightning is for it to be switched off and unplugged from everything: the 230VAC mains, modem and ethernet connection, TV and cable and so on. Even then, there is no guarantee that equipment won't be damaged – lightning is like that.

So if you do decide to buy a big-ticket electronic item, just be aware that the retailer may try to "up-sell" you. Don't be caught. And shop around for those HDMI cables and other accessories; the chances are that you can purchase them much cheaper elsewhere.

Leo Simpson

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New hearing aids are life-transforming!

I want to thank SILICON CHIP and Ross Tester for the article on the Australia Hears hearing aids in the July 2011 issue. I have just completed my first week with a pair of Australia Hears LOF models and the companion PC programmer. My life will never be the same!

The first time I wore the devices I heard my canaries singing downstairs, the front gate opening and closing, my car turn indicator merrily ticking away and a hundred other sounds and noises I had almost forgotten. Most importantly, I could understand everyone around me, even those talking behind my back.

I have been suffering from a gradual but devastating hearing loss for many years and have been searching for a solution for a long time (I even built the Jaycar/Electronics Australia "Super Ear" kit so that I could attend meetings and lectures without appearing to be the village idiot).

Unfortunately, most solutions were beyond my means or had serious technical or ergonomic limitations. I was repeatedly told by people whom I trust that the minimum I needed to spend to get a decent result was $6000 to $7000 – per ear! I also needed to make repeated and expensive visits to a clinic to set up and tune the hearing aids after I had purchased them.

Without Ross Tester's article I would never even have looked at a thousand dollar hearing aid, let alone buy it. Everything Ross wrote in the article has proved to be true. The units were powered, programmed and tested within half an hour of arriving. I have spent a small amount of time since then tweaking the frequency response but other than that they work well and I am slowly getting used to wearing them. The hearing aids, programmer and associated kit have many small touches, too numerous to list here, which make them easier and more pleasant to use and it is obvious that a great deal of thought has gone into their production.

I cannot overemphasise the importance of the programmer and the associated software in making this solution work. Not only does it allow me to tailor the output exactly to my needs but it also future-proofs my considerable investment. I am sure that my hearing will change over time and being able to track it by simply plugging in to a PC and altering the device parameters will allow me to use these new hearing aids for many years to come.

Finally, I want to mention that my small interaction with Australia Hears (two phone calls and two emails) has convinced me that they are a rare breed – a company that cares. They even rang me from Melbourne to inform me that my parcel had been misdirected by Australia Post and that it would be a day or so late. They apologised profusely even though it was obviously not their fault. As promised, I received the parcel the next day.

I have been reading your magazine for many years and have constructed many of the projects featured. It has been an entertaining, enlightening and rewarding experience but now it has also become life-transforming. Thank you everyone at SILICON CHIP and thank you Ross Tester.

Joe Moldovan,
Bondi Junction, NSW.

Solar PV systems are now economically viable

Recent press releases inferring that solar PV systems are not an economic proposition made me look again at the economics of grid-connected PV systems. I am a strong supporter of solar power and have been running a 3kW system for the last five years. Fortui-

Caution required when repairing microwave ovens

I write in response to the letter from Brett Cupitt regarding discarded microwave ovens being potentially repairable (Mailbag, October 2011). Brett states that simply replacing a blown mains fuse is all that is required to fix some microwave ovens but there is an element of danger in just doing this.

If the mains fuse is blown for no apparent reason then most likely the safety door switch has blown it, ie, someone opened the door when the oven was operating.

Normally, there are two microswitches in series which operate via the door and door latch to cut the mains supply if the door is opened when in operation. But there is also a switch across the mains on the other side of these switches. If the two switches fail or are slow to switch then the mains fuse is blown as a last resort instead of "microwaving" the operator.

This happens quite often as the switches become gummed up with gunk over time.

The danger is that once this switch has performed its task and blown the fuse, it is most likely very stressed or completely destroyed as it has just passed much more current than it was designed for. The original fault is most likely still present as well – the switches in series would still be gummed up and slow to operate.

The danger may not be apparent with most people as they wait for the timer to time out or press "cancel" before opening the door.

The usual practice is to replace all the door interlink switches if the mains fuse is blown.

Philip Chugg,
Rocherlea, Tas.

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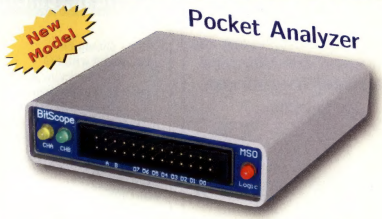
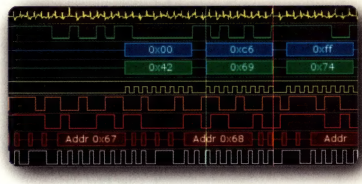
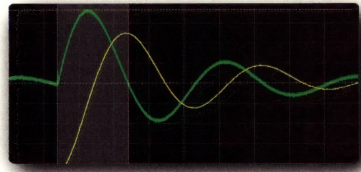


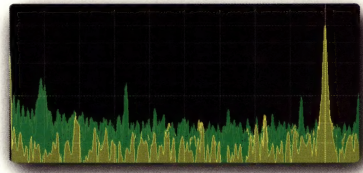
Protocol Analyzer



Digital Oscilloscope



Spectrum Analyzer



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Mailbag: continued

DAB+ should be compared with FM

With respect to Kevin Poulter's letter in Mailbag (page 6, September 2011) have searched the "Channel-News" website and I cannot find the quote stated "As Commercial Radio Australia . . ."

When DAB+ was being trialled there was over a million dollars of Government funding to test the system. The commercial stations have had to fund their own digital broadcasting; the only costs to the government has been to equip the ABC & SBS with their infrastructure. The ABC/SBS have benefited from CRA's promotion of digital radio.

The UK is not a good comparison because they are using the inferior DAB version 1 and have too many programs on a single transmitter for good sound. Now that the EU has mandated all digital radios be compatible with DAB/DAB+ and audio DMB standards, eventually the UK can convert. Australia was the first country to commence permanent high-powered broadcasting in DAB+, just two years ago.

4% of our covered population bought receivers whereas 6% of the UK population did the same. Last month, Germany just started a new national DAB+ network and they are the richest country in Europe with four times our population. (UK has three times ours). The French have mandated that all new cars sold from the start of 2013 must be equipped with a digital radio.

The Department of Broadband, Communications and the Digital Economy is yet to decide the transmission system for regional and remote Australia. DAB+ has a limited range and DRM+ is more suited to regional Australia and DRM30 to remote Australia. So car manufacturers want their radios to work outside of the mainland state capitals where 40% of our population live.

Digital TV was hailed as being a major leap forward back in 2001 when it commenced in state capital cities. Two years later the number of receivers sold was very low, like digital radio now. I don't think many would want to go back to analog TV now.

Go to a major appliance retailer in the DAB+ coverage area and have a look. The range now extends from a USB receiver ($40), through the "kitchen radios" you mentioned to mini-hifi systems to tuners. Plug a pair of stereo headphones into any of the above radios and you will hear much better stereo quality. One of SILICON CHIP's advertisers has a hifi DAB+ tuner in the September issue.

As for reception problems, you must compare FM and DAB+ because they are both VHF and not AM which operates at a much lower frequency. Compare, if you wish, AM to DRM30 which will operate at the same frequencies as AM. Gippsland has its own radio stations which are all FM, except 3GV Sale which is AM.

3AW may win the ratings in Melbourne, however at the last rating period and using the 2006 census, 38% of the population listen to AM and 55% listen to FM.

Alan Hughes,
Hamersley, WA.

tously, the system I had installed has battery back-up and this means I will always get at least the current peak rate for the electricity I generate, irrespective of what the feed-in tariff is set at.

Without any government rebates the cost of a 2kW system is now of the order of $12,000. This is broken down as $6000 for panels (10 x 200W panels), inverter/charger $2800, 10kWh capacity ex-Telstra gel battery pack $1500, two 60A solar regulators @ $400 and installation $1300. In the Sydney area, such a system will generate 3285kWh per year (my 3kW system produced 5091kWh in the last 12 months).

One advantage of having a battery back-up system is you have the flexibility of either selling the generated power to the grid or storing it and using it yourself. This means that if you missed out on a high feed-in tariff, you

will at least be guaranteed the current peak rate charged for electricity (from July 2011 this is 25 cents/kWh or 35 cents/kWh if on time-of-use "smart meter"; NSW figures). The return on the $12,000 at the 25-cent rate can now be calculated as 3285 x 0.25 = $821.25, giving 6.8% per annum.

A more serious investor would install a system with double the number of solar panels and use a larger capacity inverter/charger resulting in an outlay of $22,000 and a return on investment of 7.5%. These returns, with their guarantees (the return will only increase over the next 10 years as electricity prices increase) make battery back-up PV solar systems a very sound investment.

If you take into account the current government rebates via RECs (renewable energy certificates) then $3000 can be deducted from the capital outlay for the 2kW system, lifting the return to 9.1% pa. The 4kW system's return jumps to 10.3%.

The advantages of a battery back-up system are:

(1) If you decide not to sell your power to the grid no extra meter is required and as long as the inverter/charger has Australian approval, a licensed electrician can install the system without any approval from the electricity authorities (other than compliance with the wiring rules).

(2) The panels are all connected in parallel so there is no high voltage is on the roof. The total voltage is 30V, compared to 300V for straight grid-connected systems where the panels are connected in series.

(3) These systems are set up to automatically switch the whole or part of your house load to the batteries through the inverter when a blackout occurs. You are not aware that a blackout has occurred.

(4) The Australian-made Selectronics Inverter/Charger has been approved to charge the batteries from the grid at off-peak rates. This allows you to buy any shortfall in power from the solar panels at a rate of 7c/kWh rather than the peak rate of 25c/kWh.

(5) The low voltage of the battery side of the installation means that you don't need a licensed electrician to install extra components, such as wind generators, MPPT solar regulators, extra solar panels or sun trackers for the panels. As long as the increase in generating capacity is not too large, there is no need to increase the size of the inverter/charger as the batteries act as a buffer between the panels or wind generator and the grid.

(6) Most inverter/chargers and solar regulators have computer interfaces and software to allow you to set up data-logging, monitoring and a control system for your installation. This gives you an independent check on your power bill as well as early fault detection.

(7) Under normal daily operation, the batteries will be cycled by approximately 20% of their capacity and this should result in a 10-year life even for the ex-Telstra batteries. My original system has now been working for five years with ex-Telstra batteries and there is no sign of any battery deterioration. Using gel batteries also means there is no maintenance except for occasionally checking terminal connections for corrosion.

(8) Finally, battery back-up PV systems overcome a general criticism of solar or wind electricity generators, that they cannot be used to supply base load power. The systems proposed will adequately supply the base load of the average household. Also the figures shown demonstrate that, at a consumer level, PV systems compete very well economically with coal-fired generated electricity.

Dr R. D. Bell,
Glenorie, NSW.

Definition of pump "head"

I want to make a clarification/correction to the definition of pump "head" given on page 23 in the September 2011 issue, viz, "A pump has to be able to pump 120-180 litres per minute against a reasonably high "head" (eg, the depth of the pool plus height of the pump above the pool)".

The depth of the pool has no effect on the head measurement. It does not matter if the intake pipe is at the bottom or top of the water column, the head is still only the distance from the top of the water to the pump. Otherwise, it is an interesting article.

Colin Carpenter,
Mosman Park. WA.

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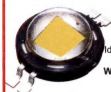

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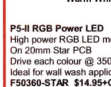

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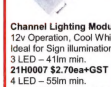

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Mailbag: continued

Modern appliances have very little stand-by power

I have enjoyed reading your analysis on so-called energy saving devices on the market and the September 2011 article about ways of reducing our power bill made me think about our power usage. I even went and bought one of the cheap meters you mentioned to measure the power usage of various appliances.

It has been an interesting exercise to tabulate the various consumption figures and corresponding costs, and to see the annual cost change as I vary the usage time (in a spreadsheet). The surprising discovery in all this has been how little power modern appliances seem to use on standby.

The following costs are based on 24-hour connection and 24 cents/kWh:

81cm LCD TV: 0.4W, $0.84 per year
STB/PVR: 1.1W, $2.31 per year
DVD player: 0.5W $1.05 per year
55cm monitor: 0.7W $1.47 per year

These figures seem to line up with what I believe is the European standard which requires a standby power usage of less than 1W to be considered "green".

Some of my older appliances used more power on standby:
Masthead amp: 3.2W, $6.73 per year
CRT TV: 5W, $10.51 per year
VCR: 6W, $12.61 per year
Modem/router: 5.5W, $11.56 per year
Microwave: 3.1W, $6.52 per year

Even at these figures, you would need several old TVs and VCRs to make up the hundreds of dollars the popular media tell us we are wasting with standby power each year.

Certainly turning off computers, CRT monitors/TVs and VCRs when not in use can reduce the power bill a bit. Of course, turning off three 50W downlights for an hour or a 2400W heater for four minutes, will save more than leaving the VCR in standby for 24 hours – and you wouldn't need to reset the clock.

The other thing I observed is a useful rule of thumb formula. At 24 cents/kWh (the cost according to the bill I got last week), it is simply a matter of doubling the standby power in watts, to give the approximate cost per year.

For example, a TV with a standby power of 5W will cost just over $10 per annum.

Geoff Stanbury,
North Nowra, NSW.

Comment: most new appliances these days have a standby power of 1W or less, as you have observed.

Caution on use of DC Isolator switch

I have a couple of comments on the letter by Chaim Lee in the Mailbag pages of the September 2011 issue. Chaim commented on opening the DC Isolator while the system is operating and voiced his concerns about the voltage rating of the switch and the arc produced when the switch is opened.

The issue here is that you do not open the DC switch with the system operating. You must turn off the AC switch to the inverter first. This shuts down the inverter, taking the load off the DC circuit, thereby making it safe to open the DC switch which then has no current flowing through it.

My installer warned me to never open the DC switch before shutting down the inverter as the DC switch can be damaged by the substantial arc formed when the contacts are opened under load. The rating of the switch at 500V DC is adequate, because the inverter input is 150V to 400V DC.

The absolute maximum (peak) inverter voltage input must not exceed 500V DC or you will risk damaging the inverter. We have 14 panels in our system which are connected in series/parallel to produce a maximum voltage of 385V DC. Chaim's panels should be

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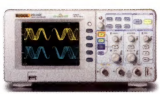

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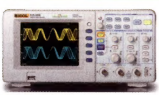

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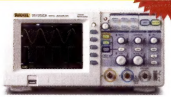

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connected series/parallel, to produce a maximum DC voltage of 275V DC.

Chaim indicated that solar installations are not inspected by Ergon Energy inspectors. This statement appears to be incorrect, as when our solar installation was done, we had two inspections by an Ergon Energy inspector. The first inspection was of the installation itself, which was not allowed to be powered up until it had been inspected, and the second inspection was of the newly installed meter which monitors the feedback into the mains.

My DC isolator has the following markings: Ue 500VDC; In 20A; Uimp 4kV. This switch passed the electrical inspection, so the rating must be correct.

Earthing of the solar panels could be a concern. We have a steel roof and a steel-framed house. The panels are therefore connected to the house, however, the only earthing of our house is through the earth stake, which in the case of a lightning strike hitting the house could result in damage to the electrical wiring.

I am considering installing a more substantial earth stake connected directly to the steel frame of the house, separate to the electrical system. I think it is also of concern not to have the metal roofs of houses and metal sheds earthed, to reduce the impact of a lightning strike.

Bruce Pierson,
Dundathu, Qld.

Comment: your point about not operating the DC isolator switch when the inverter is going is a good one. Nevertheless, the required DC isolator is apparently required to be rated at 1000V since 500V gives an insufficient margin above the 400V that can be delivered from the solar panel array.

Also consider that in an emergency, such as a house fire, the DC isolator may have to be turned off without being able to turn off the AC output from the inverter.

In any case, we would take issue with your comment that "This switch passed the electrical inspection, so the rating must be correct." These days, just because an inspector passes something, does not mean that the correct practice has been followed.

We agree that earthing of steel roofs is a concern. Australian Standard AS1768.2007 covers this topic in detail.

Relay protection circuits can suffer from welded contacts

The revamped Speaker Protector design in the October 2011 issue is certainly a good basic design and I have fitted about a dozen of the earlier type with good success in recent years. This may be due to the relay itself being a better type than even older designs or just the well-proven circuitry you have employed for many years.

Whilst I recommend the Class A Amplifier design at every opportunity, I am fundamentally dubious of relay protection, having had two different amplifiers fail with welded contacts over 30 years. This is with higher power (200W & 250W) designs that probably were capable of welding too! The alternative of a crowbar is not so comforting either but use of a very low resistance Mosfet SSR (solid state relay) is quite attractive to audiophiles, who are always anguishing over the parts in the audio chain.

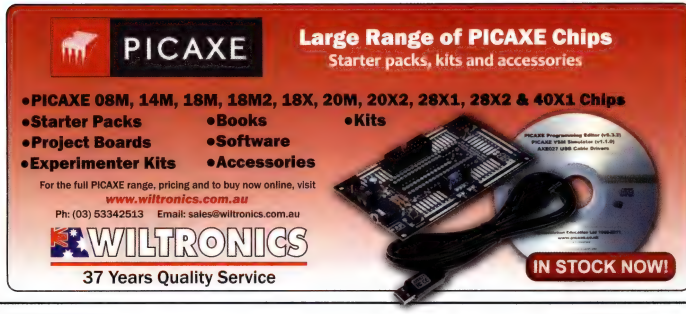
Ian Finch,
Urunga, NSW.

Comment: one of the features of our Speaker Protector circuit is that it uses a heavy-duty relay which is rated to break heavy currents. Relays with lower ratings could easily suffer from welded contacts and as you say, this would be a big risk.

We are not keen on crowbar circuits and solid state relays in the output signal path are not desirable as they will inevitably increase distortion. The big fat relay, combined with the fuses in the amplifier supply rails, is the cheapest and most effective protection.

Do something about rising electricity tariffs!

Reading the Publisher's Letter entitled "Rising Electricity Tariffs Causing Hardship For People On Low Incomes" and the article "Can you really reduce your electricity bill?" in the September 2011 issue of SILICON



Mailbag: continued

Distortion is a complex subject!

It was interesting to read the letters and comments on audio distortion and allied subjects in recent issues of SILICON CHIP. As an audio enthusiast myself I prefer to keep audio distortion levels as low as possible but the way the human mind "interprets" distortion is far from black and white.

I have a number of audiophile friends who much prefer the "sound" of so-called SET (single-ended triode) valve amplifiers, yet these kinds of amplifiers traditionally produce large amounts of distortion (mainly second harmonic), which in large part gives them their "sound". Indeed, I also know of audio people who regard very low audio distortion as sounding "lifeless and boring"!

In any case, I believe that there is a distortion "threshold" at which distortion becomes audible. I myself am quite sensitive to even low levels of audio distortion beyond a certain distortion "threshold".

In my own high-fidelity DIY work with op amps, my preference is to use the popular OPA2134 dual op amp. It is an excellent audio device with very low audio distortion, yet there are now even lower distortion high-performance op amps available. Are they worth the asking price? In my opinion, no. I'm very happy with the OPA2134 and I'll stick with them!

Felix Scerri, VK4FUQ, Ingham, Qld.

CHIP had me struggling to understand the stance of your magazine. I was surprised that both articles appear to be dismissive of the benefits of energy-saving measures.

The reality is that the cost of generating electricity is rising and will continue to rise as the finite resources of non-renewable energy are drawn down, causing upward pressures on resource prices. The cost of generation has upward pressures too, as attempts are made to reduce the social and environmental impacts of power generation and as demand for energy accelerates. This is despite the reduction in costs of infrastructure, energy generation and distribution through restructuring and private sector ownership, which has occurred over the past 20 or so years.

It is true that the solar rebates offered by governments have been generous. It is also true that the rebates are unsustainable. And it's possibly true that the same amount of money spent in a different way may have produced a greater effect, if you ignore the behavioural changes the stimulus packages have fostered.

I was once cynical about the benefits of small-scale domestic solar electricity generation schemes. I believed that solar power generation was best suited to locations where the cost of reticulated power was prohibitive, for example remote outback settlements and telecommunication outposts. The overall cost, complexity and poor inherent system reliability of a combination of solar panels, batteries and inverters didn't seem to make much sense.

However, I made a decision to install a small grid-connected domestic solar generation system for purely financial reasons. It wasn't particularly to be "green" and I certainly didn't have spare cash to throw around. But I could see no end to the escalation of electricity prices and in fact price rises seemed to be accelerating. My 1.5kW system cost me around $3000 installed, thanks to the government rebate schemes.

I can assure you that the change to solar power has had a profound effect on my life in ways I never envisioned. That change in behaviour, repeated many thousands of times across the population of solar adopters, it is exactly what the government stimulus was meant to achieve.

I get a return on my investment by selling electricity generated surplus to my needs back to the grid. In order to maximise my return, I have to not use the electricity myself! That is where the game changed for me. Schemes like the one in NSW which reward the generator by rebates for gross generated power, rather than net power returned to the grid, are ill-conceived and probably have the effect of letting people "off the hook". That is, they give a people a sense of being "green" without them having to change their behaviour, a counter-productive result that comes at a cost to everyone.

I thought my household was already

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Mailbag: continued

Cells are not batteries

An article in the October 2011 issue of SILICON CHIP has highlighted one of my pet "peeves". Circuit Notebook (a feature that I really appreciate) featured a "Simple Lithium-Ion Battery Charger" circuit , submitted by Graham Jackman.

I have no comment about the circuit itself or its efficacy but take issue with the nomenclature used in the heading and the text of the article. Throughout the text the word "battery" is used where the word "cell" should have been used. By definition, a "battery" is a collection of cells. As an example, a 12V car battery is composed of six 2V cells.

The circuit that Graham has submitted will (as depicted) only charge one lithium-ion CELL. If a *battery* of two (or more) cells was connected to this charger, it would not work – the relay would not close. So folk connecting a battery to this project will be disappointed.

You may think that I am nitpicking but SILICON CHIP is an electronics magazine and I feel that the use of correct terminology should be maintained, in spite of what "common usage" terms may be used amongst the folk buying "batteries" at the supermarket.

Anthony Mott,
Blackburn, Vic.

Comment: quite right, Anthony. We have been far too sloppy. The junior staff members responsible will be taken out into the car park and given a good flogging with the Editor's favourite and most appropriate weapon of punishment, the "Cat-of-5" tails (made from Cat.5 cable)!

a low energy consumer at around 12kWh per day but I have now halved that to just over 5kWh per day. I live in a normal house with all modern conveniences and do not forego any of the comforts of modern life. Yet many families I know consume 40kWh or more per day. I now generate about as much power as my household consumes and the payback period for our solar generation system is just three years.

There is a lot of talk about the embedded energy in the manufacturing of solar panels. But modern panels take around just two to three years to generate the amount of energy used in their manufacture. After that there is a net benefit for the next few decades of the panels' working life.

Grid-connected solar generation schemes have another benefit that is often overlooked; they generate power at, or very near, the site where it is used. Conventional high voltage step-down distribution systems for transporting electricity from the power station to where it is used have losses of around 50%. To replace 1kWh of solar generated power, you need to generate 2kWh of coal or gas-fired power!

It staggers me how our civilisation is so wasteful with resources when they are cheap, ie, when they are not running out. Of the original energy embedded in coal or gas, around 10-15% is used in the process of extraction and transportation to the power station, 50% is consumed in conversion losses and running the power station, then 50% of what is left is dissipated in the transmission grid.

Just 20% or one fifth of the energy dug out of the ground makes it to your house as electricity!

But waste doesn't stop there. In general, power isn't managed any better in the home. For example, when I was chasing down high power bills I discovered the garage door opener was very hot. The unit I had is an extremely common remote control door opener, which uses a large 240V-to-24V step-down transformer and a 24V windscreen wiper motor to operate the door lifter.

The control system acts on the low voltage side of the transformer, meaning that the transformer sits live all of the time and dissipates magnetic hysteresis and eddy current losses. The static dissipation turned out to be 60W or 1.4kWh per day, just for the door opener to wait to see if I pressed the button on my remote control. On top of that, the dissipation is inside the house, where it will add to the heat load that needs to be removed by air conditioning in summer.

Let's say I open the door twice each day. The energy used to actually operate the door is only around 0.017kWh per day or just 0.0012% of the total energy the door opener consumes to provide this convenience. I find this degree of waste to be staggering . . . and not at all uncommon!

I have reduced the standby power consumption in my own household by around 1500kWh per year ($300-400) by eliminating unnecessary plugpacks and clocks, choosing appliances that disconnect from the mains when they are turned off, switching off appliances that have high standby power consumption at the circuit breaker and changing to high-efficiency supplies for items that need to be left on.

Once the background consumption is addressed, seemingly small reductions in energy consumption, like changes to high efficiency lighting, become much more significant. Addressing insulation and maximising solar heat gain in winter whilst preventing heat gain in summer has eliminated the need for heating and cooling on almost all days of the year in my house in Adelaide.

Since installing the grid-connected solar generation system a couple of years ago, I have only ever got credit from my electricity supplier. I do realise this would not be the case without the cross subsidy from other consumers because I would still have to pay for connection and service fees, however even if the feed-in tariff was removed there would still be an enormous and rapidly increasing net benefit both to me and society.

Rather than gripe about the fairness or cost of solar rebates, why not do something to use less power and lower your electricity bills? It isn't necessary to forego the comforts of modern life and you can take comfort in the knowledge that you will be contributing less proportionally to the rebate schemes!

John Matheson,
Unley, SA.

My DAB+ radio has been mothballed

In reference to Joan Warner's letter (October 2011) where she defends the introduction of DAB+, her comment about the number of digital radios sold is not an indication of how many are actually in service. My children gave me a Grundig digital mantle radio for Father's Day last year. Sadly this has remained in its box as the reception here in Penrith is almost non-existent, and Penrith is in the service area of the Sydney stations.

I am sure I'm not the only person to "mothball" a DAB+ radio after being disappointed with the service. In my home, I can only use the radio in one upstairs bedroom and I have to fiddle with the antenna to get a reliable signal, readjusting it each time I change stations.

This is certainly not progress. You may well be correct about the audio quality however I have never had a good enough signal to hear for myself!

Dallas Haggar,
Glenmore Park, NSW.

Comment: if it is possible, connecting the radio to a TV antenna might greatly improve your DAB+ reception. SC

Building an eBike

POWER your (Puff,

Riding a pushbike is great exercise – until you come to hills! Unless your name is Evans or Armstrong et al, unless you're one of the lycra brigade who keep super fit by pedaling everywhere and anywhere, even if your pushie has 150 gears and weighs about a hundred grams, you often wish that you could have just that little bit of assistance when the going gets tough!

By Ross Tester

My first pushbike came courtesy of Santa when I started high school. And I've had one (or more) ever since. While I enjoy riding my pushie and acknowledge that it's one of the best forms of exercise, I'm the first to acknowledge that I'm not quite as fit as I once *thought* I was.

In fact, riding for any distance (with the emphasis on any!) certainly takes it out of me. So often I've wished for a motor of some sort to ease all those strained muscles, especially walking the bike up hills that have beaten me!

Building a bike for the teacher

Some months ago our esteemed editor and I visited a school which regular readers would be familiar with because we've featured it before in SILICON CHIP: Mater Maria Catholic College in Warriewood, near our editorial office on Sydney's northern beaches.

We were there at the invitation of Dave Kennedy, the school's electronics/technology teacher, to review the major projects being built by his senior students for their Higher School Certificate.

Most of those projects came from the pages of SILICON CHIP; many were variations on those projects (and those variations were where some of the builders struck snags!).

Having spent the best part of a day talking to the students and solving (we trust!) many of their problems, we were intrigued to spot what was going on (through the glass) in the classroom next door. Here his younger (year nine) students were building an electric pushbike.

In fact, Dave Kennedy had purchased a brand new pushie (nice bike, Dave!) and an electric motor conversion kit specifically for the students to gain some "hands on" experience.

The bonus was that when it was fin-

Puff) Pedal Pushie!

ished, Dave could ride to school – about 5km or so across mainly flat terrain but with a nasty hill at each end. It was for these hills which Dave hoped a motor would keep him from becoming too hot and bothered when he reached school each morning.

The completed bike looked pretty impressive – from the fire-engine red frame through to the in-wheel motor and controller, along with all the controls and wiring necessary.

One of the students, Alex, even took a few photos of it for us.

But this started us thinking – why not a project in SILICON CHIP showing how to build an electric bike (or, to be more accurate, how to convert an existing bike to electric-assist).

By the time we got back to the office, the editor and I were convinced that many readers would like to know how they could bring that old pushie back to life (you know, the one with flat tyres hanging on the garage wall!) and perhaps get some benefit by way of (power assisted) exercise.

So we approached the distributors of the kit which Dave Kennedy had purchased – Rev-Bikes in Victoria (www.rev-bikes.com) [see end of article] and this article is the outcome.

Legal or not legal?

This was our first question. Is it legal to put a motor on a pushbike and use it on public roads?

We're not lawyers (even of the bush variety) and it took a bit of digging to get the answer.

This appears to us to be yes. . . but!

The rules appear similar (if not identical) in all states but we will use NSW regulations as our yardstick.

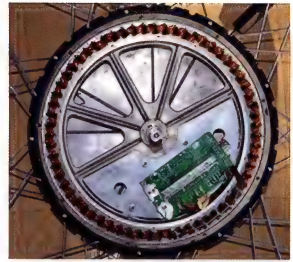
Quite simply, according to the NSW RTA website (www.rta.nsw.gov.au/registration/unregisteredvehicles/scootersminibikes.html) you can put a motor on a pushbike with the aim of assisting pedaling, as long as the output power of that motor does not exceed 200W.

There are two points to note here: first is the motor is not intended to replace pedaling as the means of propulsion – it is there to assist.

Indeed in most European countries the motor doesn't work at all unless the pedals are being pushed (thankfully, they haven't brought that one in here . . . yet!)

The second point is that limitation of 200W. To be frank,

The Year 9 class from Mater Maria with the newly-converted "Diamondback" mountain bike. At left is Malcolm Faed, whom readers will recall converted his ute to battery/electric power (June 2009 issue).



Lay out all components on a table or clean floor to check that you have everything. Here the tube/tyre is already fitted and there are some differences between this kit (the Mater Maria kit) and the one we used. At right is a shot inside the "Magic Pie" motor, which also shows the integrated controller.

that's not much at all, especially if it is pushing around a 100kg rider. Again, it will only assist you, not really propel you.

There are lobby groups currently trying to have that raised to at least the European standard of 250W – again, not much, but better than 200!

If the motor is rated at higher than 200W, then the pushbike becomes a motorbike and must be registered as such – except that it is almost impossible to do so because the "motorbike" does not have all of the equipment demanded by Australian Design Rules, such as turn indicators, brake lights and so on. Catch 22 all over again!

Just as importantly, the rider must be licensed to ride a motor bike – again, impossible if they are under age.

How are the motors tested?

As far as we are able to ascertain, authorities (Police, traffic, etc) cannot test motorised pushbikes in any state, simply because they do not have any equipment to do so.

In most cases, the motors (especially in-wheel types) do not have any power or other identification on them so the boys in blue cannot even look up a reference to say "You're nabbed!"

Anecdotal evidence suggests police tend to use their own judgement – if you are whizzing along a road at 50km per hour, not pedaling, they might take a slightly more jaundiced view of you than where you are riding at a slower speed and at least appear to be pedaling!

So which motor to go for?

We'll get on to motor specifics in a moment but the source we obtained our motor from has several different models available – not only various sizes (to suit most bikes available in Australia) but also in power levels.

First is a 200W motor so it is absolutely legal, regardless. It's also the cheaper alternative.

Second is a much more powerful motor – rated at 1000W – which can be "governed" down in output power via the use of a computer program.

As perverse as the high power motor option sounds, that's the way we went for the SILICON CHIP pushie power conversion. Why?

Most importantly, the higher-power motor programmed down would be operating way below its maximum rating, therefore its longevity is much more assured. A 200W motor would be operating at maximum most of the time, therefore wear and tear would be expected to be much more a factor.

Secondly (and yes, this does sound like a cop-out!) we knew that we would have the opportunity to use the bike on some mountain bike tracks on private property where that extra power would come in real handy. By taking along a notebook computer, it would only take a few moments to re-program the motor to full power and back down again.

Having said all that, SILICON CHIP does not endorse, in any way, the fitting of an over-powered (ie, >200W) motor to a pushbike for on-road use.

Front or rear . . . or both?

There is one other consideration, that is whether to fit the motor to the rear, to the front or even (as we have seen in pictures only), both front and rear!

Assuming you're only going to fit one motor, there are arguments for both fitting to the rear and fitting to the front.

The rear, which suits a 135mm fork width, should mean best traction, because it is driving the wheel which is normally driven by the pedals/chain. However, this puts a lot more weight at the rear of the bike, possibly resulting in less control (eg, steering can be a little "vague", etc).

A front motor, (100mm fork width) should be easier to fit (no problem with gears etc) and also the weight is more evenly distributed, which theoretically at least, gives the best control.

Fairly obviously, fitting a motor to both front and rear would result in a lot of power – but it would also be just as obvious that you were running significantly more than 200W and could automatically draw the attention of the authorities that you don't really want.

It would also be a quite expensive exercise, not to mention the difficulties of controlling those two motors as one.

One further point: regardless of the motor to be fitted, they aren't suitable for carbon-fibre or other lightweight bikes. You need a strong, steel fork to take the strain.

Which battery?

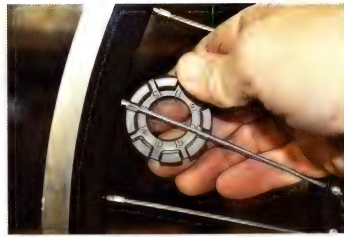
There's a range of batteries available to not only suit the motor you choose but also give extra performance.

The voltage of the motor you install determines the amount of power or torque you will get; the higher the voltage, the faster the take-off.

Our kit came with a 48V motor so we obviously needed 48V battery. The one supplied was a Li-ion type but you'll find other types to choose from on the Rev-Bikes website.

For example, they also have LiFePO4

The wheel as supplied with a 1000W Magic Pie 48V in-wheel electric motor. This is one of several models available.



The spokes are usually loose to prevent warping in transit. A $6 spoke key soon had them nice and tight.

types 24V (16Ah), 36V (12 or 16Ah) or 48V (10Ah). LiFePO4 are more expensive but charge in half the time as Li-ion and last twice as long.

All come with a mains charger (an optional solar charger is also available). A battery management system monitors each cell within the battery for the longest possible life.

The range with a fully charged battery depends on the type and capacity but as a minimum, you would expect 30km or so per charge without significant regenerative braking.

The kit

Meanwhile, back at the ranch . . . we approached Rev-Bikes and explained who we were and what we proposed. They were most helpful in our discussions and agreed that an article in SILICON CHIP would be a great idea.

So within a few days, a large package arrived from Rev-Bikes and we got ready to attack a perfectly good Dunlop 26" mountain bike.

Well, attack is probably a bit harsh as you don't have to make any real changes to the bike, except for fitting the motorised wheel, the battery and all the controls.

First of all . . .

Lay all the components out on a table or garage floor to ensure that everything is supplied. It also makes life easier later on if you identify the various components now. The photo actually shows the Mater Maria kit which is slightly different to that which we obtained.

Charge the battery

While going through the various assembly steps, it's a good idea to plug the battery into its mains charger so that when you want to use it, it's fully charged.

The battery charger plugs into a socket on the battery pack which is revealed when you raise the handle 90°. The battery does not have to be plugged into the motor or controls to charge.

Fit the tube/tyre

The wheel rim is "double walled" to ensure that it can handle the enormous torque generated by the electric motor. Apart from that difference, fitting the tube and tyre is exactly the same as on a conventional wheel, with the possible exception of the valve stem.

Rev-Bike suggest buying a tube with a long valve stem to go through the double wall and also avoid pressure on the tube if stretched; these should be available at better bike shops.

(I'll admit that I used the existing [standard stem] tube and tyre. It takes a bit of manipulating but it is possible to use a tube with a standard-length valve stem).

Fit the gear cassette

When I was a kid, they used to be called gear clusters – the multi-gear assembly for chain gears. A new one will cost about $30 but we wanted to use the existing one and save the money.

If you are doing so, you may need help in removing it – there's a special tool which does the job in seconds. My local bike shop did it for me without charge. While you've got the gear cassette off, a good clean with some kero and a wire brush won't do any harm!

Fit brake disc (optional)

If your bike has disc brakes, there is provision on the motorised rim for fitting. Otherwise, you use the existing caliper brakes but note that you may need to reposition the shoes. In fact, we found it easiest to remove the brakes altogether while fitting the wheel – they just get in the way.

Not only that, you'll be fitting new brake handles so will probably have to replace the brake cables as well.

Loose spokes!

As we were examining the components, we were a little perturbed to find most of the spokes in the wheel rather loose. Apparently this is normal practice to avoid the wheel warping in transit (something we didn't know about).

With the aid of a spoke key ($6 at the local bike shop) we proceeded to tighten all the spokes before we went any further.

The easiest way to do this is to use an old front fork mounted vertically (eg, in a vice). You'll almost certainly need to bend the forks apart a little to accommodate the wider rear wheel hub. Loosely mounting the wheel in this fork will not only make access simple but allow you to spin the wheel easily, looking for any "wobbles" or warped sections caused by too loose or too tight spokes.

Remember that you tighten the spokes on the opposite side of the warp to pull the rim back to the centre.

You also need to ensure that the motor/axle is centrally located within the rim. If the rim moves up and down as it rotates, that needs to be corrected. You tighten both sides by the same amount to pull an eccentric (out-of-round) rim back in. It's a trial and error routine;

Fitting the tube and tyre is much the same as a "normal" bike wheel. Rev-Bikes suggest using a tube with a long valve stem, but we elected to use our old tyre and tube. As you can see the valve stem pokes through the double-wall rim with more than enough length.

They call them gear cassettes – this one came off the original wheel and was easily fitted to the new (powered) wheel – it simply screws on.

you may find that correcting a warp results in the wheel being more eccentric – or vice versa.

Make small adjustments – no more than half a turn at a time – and when you think you've got it right, it's best to leave the wheel overnight (or at least a few hours) to allow it to "settle".

Fit the wheel

The powered wheel slots into position in the same way as the original. However, you may need to pull the frame apart slightly (maybe 10mm or so) to fit the new wheel. It helps to have a second person on hand to assist with this.

The power and control wires exit the hub on the left side (ie, the side opposite the chain/gears). To keep them from getting tangled in the wheel etc, while building, loosely fasten them to the frame with a cable tie.

It is important – in fact it's vital with a powered wheel – that the wheel nuts are done up as tight as you can get them. Ideally, you should use a ring spanner or socket for this – don't use a shifter because they ruin far more nuts than they do up!

It's also vital that the wheel is placed exactly on the centre line of the bike – there should be exactly the same distance between the rim and the frame on both sides. This is no different to any wheel you fit to a bike. Similarly, the wheel should have no wobbles nor eccentricities (see earlier notes).

Torque Bar

You might also consider the installation of a Torque Bar, which is designed to ensure the axle doesn't slip in the forks. This is particularly necessary where high voltage motors are pulling a lot of weight, or in certain kinds of forks which don't lock the axle in well. These are also available from Rev Bikes for $25.

Check the chain/gears

The gear changer (derailleur) is obviously fitted during the previous step (under the axle nut) but before going any further, check that it travels freely and the chain also travel freely within it and around the gears. Move the gear lever so that the gears change from lowest to highest gear – a small adjustment might be needed on the derailleur if the actual gear positions are different on the powered wheel.

Re-check tightness

We don't want to harp on it but for safety's sake, go back and check that the wheel nuts are still tight and that the wheel hasn't moved. While you're about it, check your front wheel nuts too – you can't be too careful.

Fit the battery plate to the battery rack

The battery is designed to slide in and out on a plate fixed to the battery rack. Once in place, the key which controls the bike locks the battery box in place via a pin into the plate.

The battery plate fastens to the rack via four 6mm screws with Nyloc nuts. A washer under the head of each one allows a little play until you get the position correct.

Note that the hole in the plate (which the pin mates with) goes toward the front. This way the key is also towards the front and the handle on the battery box goes towards the rear.

Fit the battery rack

The two vertical bars screw into two holes on the bike frame, immediately adjacent to the axle. Most bikes these days have these and they are invariably tapped to 6mm.

The front of the rack connects to the bike frame via two short extension arms (in the kit) which can be adjusted fore-and-aft to place the rack just where you want it. They're obviously intended for bikes with horizontal holes through the frame.

Where your frame doesn't have suitable holes, the two extension arms need to be secured to the frame, immediately below the seat (saddle) stem. There's a variety of bike frame designs so you will have to make the best arrangement for your frame. Just remember that the battery pack is one of the heavier components – you certainly don't want it coming adrift as you're riding along.

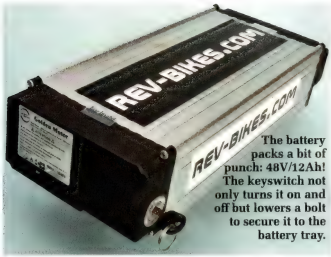
Fit the handlebar controls

Four "controls" need to be fitted to the handlebars. The obvious one is the throttle control/battery level indicator – in our kit, it was a lever type but there is also a twist-type available.

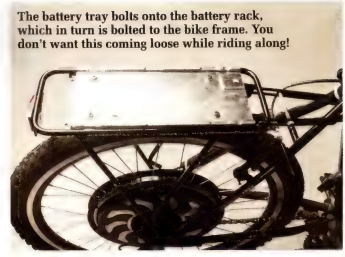
Whether you fit this to the right or left is a matter of preference – we chose the left side because it appeared to be designed this way. Also, on a pushbike, you should be giving hand signals with your right hand, so your left hand remains on the control/handlebar. But how long is it since you've seen a pushbike rider give a hand signal?

However, there is also an argument for fitting it on the right because motorcycles and scooters usually have their throttles on the right.

The second control is the cruise and



The battery packs a bit of punch: 48V/12Ah! The keyswitch not only turns it on and off but lowers a bolt to secure it to the battery tray.



The battery tray bolts onto the battery rack, which in turn is bolted to the bike frame. You don't want this coming loose while riding along!

horn buttons – these logically go on the opposite side to the throttle.

The other two controls are the special brake handles. As well as the mechanics for pulling the brake wire (just as any brake handle) these also contain a switch which engages regenerative braking whenever the handles are squeezed (ie, the motor becomes a generator and returns some electrical energy to the battery when braking).

To fit any of these controls, you're going to need to remove the handlebar grips. If, as in our case, those grips have been in place for a few years, no amount of twisting or tugging will remove them – we had to cut ours off with a box cutter knife. Fortunately, a new pair of grips is included in the kit (NOTE: don't fit the new ones until you are absolutely sure of the position of everything else!).

Another fly in the ointment could be your chain gear shifter(s). On our bike, the shifters were mounted close to the grips – just where we wanted to mount the throttle and cruise/horn buttons. So we had to move them towards the centre of the handlebars.

Mount everything just tight enough to keep them in place – that way, you can move everything around so that nothing interferes with anything else.

Pay particular attention to the gear shift levers, brake levers and throttle controls – take them right through their travels and adjust their positions as necessary.

When you're happy with the position of all the handlebar controls, tighten everything and secure the cables to the handlebar post or frame with cable ties.

As a very last step – and possibly only after you've ridden the bike for a few hours – push the handlebar grips into place. The reason this is the last step is that they are rather difficult to get off once on!

Connecting it all together

This section appears to be the most challenging but is actually relatively easy, as all the connectors are colour coded. So all you have to do is connect colour to colour and you shouldn't go astray.

The biggest problem you will have is the length of the cable – it's obviously made to handle much longer bikes (a tandem, perhaps?) and you will have the best part of a metre too much.

It would be tempting to cut and re-solder all the connectors so that the right length of cable remained but we thought that was tempting fate (and was also too much like hard work!) so we wrapped the excess cabling around the underside of the battery rack and made it as neat as possible with cable ties.

Also use cable ties to secure the bunch of cables to the bike frame in as many places as you want – just remember to keep clear of any bare brake or gear changer cables.

Slide in the battery

The (now fully charged!) battery pack slides onto the rack via the adaptor plate you fitted earlier. When it is fully home, turning the power key on the battery pack also lowers a "bolt" through a matching hole in the adaptor plate, locking it in place.

Finishing the cabling

Now it's time to connect the control cable and power cable. These mate with the two cables emerging from the motor.

Make sure the key is in the off position before this step.

The control cable has a multi-way connector. If you look closely, you'll see arrows on both plug and socket – line up the arrows and the two halves should mate easily. Push them all the way home – they are waterproof when fully engaged.

Be careful with this: it's quite easy to get them off alignment and if you do (we did!) you'll end up with bent pins in the connector (we did!). This has only one minor drawback: your bike won't work! (It didn't!)

If you do manage to bend the pins, you're going to need a pair of very fine needle nose pliers, a good magnifying glass and a strong light.

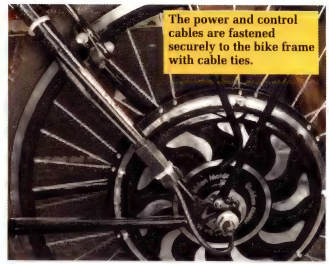
Finally, connect the power cable, + to + and – to –, to the only cable left emerging from the motor. The opposite end of this cable has a large plug which connects to the battery output. It is polarised but make sure you haven't forced it in the wrong way – again, it's + to + and – to –.

We found that one of the connectors in this plug had pushed too far back to make reliable connection – a judicious rearrangement with a pair of fine pliers soon fixed this problem.

Checking it out

We know you're itching to turn it on and ride off into the sunset but before you do, check (and tighten if necessary) all Allen screws, Phillips screws, nuts, etc – your safety depends on everything being ship-shape. Most important (again!) are the two nuts which hold the powered wheel on – the motor means there are very large stresses on the wheel so tighten it up!

The handlebar controls: on the left, the throttle/battery level meter behind the rear brake lever (both new) and gear lever; on the right the bell and gear lever, with the new cruise/horn button and front brake lever.



The power and control cables are fastened securely to the bike frame with cable ties.

Also tighten any cable ties fully and snip their ends off, mainly for neatness but also to ensure that any ends don't interfere with brakes or any of the controls. And it's better to have too many cable ties than not enough.

Boxing it up

A large box was supplied to contain all of the cable connections, to keep them out of the weather.

We thought this was a bit of overkill and will be substituting a small jiffy box instead; something unobtrusive that will sit in front of the battery box.

Pedelec (PAS)

You may have noticed that we haven't bothered fitting the Pedelec controller – that's the device which allows the motor to run only while the pedals are being used. As mentioned earlier, it's a requirement in most, if not all EU countries but it is not a requirement in this part of the world.

If you do want to fit it you'll find fitting instructions on the website in the section on Programming. As it's not required here, we didn't bother with it.

Other "options"

You will notice on the lever throttle (which doubles as a battery level indicator) that there is a push-button switch with the word "lights" underneath. Similarly, on the other handlebar control there are two push buttons; a green button which is the cruise control and a red button for a horn.

The cruise control is self explanatory – it works the same way as a cruise control in a car. Once activated, it will hold your speed (as best it can) at the same level until you either push the button again or activate either of the brake handles.

The other two buttons are for options – not surprisingly, they are for lights and a horn. Because you have 48V available, a very bright head and tail light can be fitted, as can a much louder horn than you'd expect on a pushbike.

The wiring diagram (Fig.1) shows both these options and how they are fitted; if you don't have them don't worry – just ignore their fitting on the diagram.

Programming

The electric motor should work with-

Fig.1: this wiring diagram, taken from the Rev-Bikes website, leaves a lot to be desired. Fortunately, the various plugs and sockets are colour-coded so it's reasonably straightforward to connect everything.

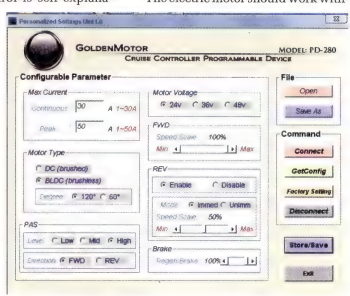
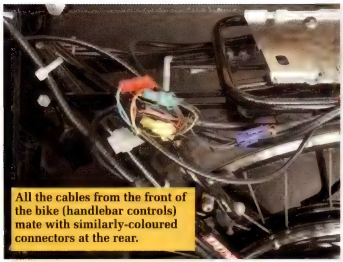
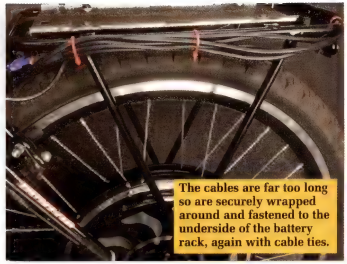


Fig.2: a screen grab of the programming software. It too is not particularly user-friendly, especially when it comes to setting that important power limit. As mentioned in the text, we'd be inclined to set maximums to 25% and hope for the best!



All the cables from the front of the bike (handlebar controls) mate with similarly-coloured connectors at the rear.



The cables are far too long so are securely wrapped around and fastened to the underside of the battery rack, again with cable ties.

out any programming on your part (ie, with the factory defaults). However, if you used the 1000W motor, it must be re-programmed down via the supplied USB cable before you can legally take it on public roads.

Download the Cruise Controller Programming Interface Software from www.rev-bikes.com.

It's a .rar file which you'll need to unpack, then load the resultant "PI200Setup.exe" file and you're away.

The USB cable plugs into the multi-pin connector which goes to the motor. The screen should look something like Fig.2 – and you can change any of the parameters you want. The motor is BLDC.

How do you set the power? If you set the power to minimum we believe you should be pretty close to the mark.

Theoretically, the minimum for a 1000W motor is 300W but if you allow for less than 100% efficiency of the motor – you'd have to be reasonably close. As we mentioned earlier, no-one has the means or equipment to measure the motor output anyway!

Security

With around $1300 worth of motor and battery, we imagine that an eBike would be a juicy target for thieves.

Of course, you could chain and lock your bike up when you leave it and always remove the key (which locks the battery box in place).

But we'd be more inclined, if at all possible, to remove the battery box completely and take it with you when not in use. That will make it so much harder for someone to purloin your powered pushie!

Conclusion

It's a wee ripper! Even programmed down, on the flat the motor managed to haul my 100kg around with apparent ease and on hills, you certainly notice the assistance from the motor.

The regenerative braking kicks in as soon as you touch the brake handles – it's nice to know gravity is giving you something back in the way of energy!

SC

The finished eBike. Apart from tightening the spokes, total time to complete was only a couple of hours. It's still a standard mountain bike (albeit several kilos heavier!) which can be ridden normally if the battery goes flat.

WHERE FROM, HOW MUCH?

Our kit came from Rev-Bikes Pty Ltd, of Melbourne, Vic. Phone (03) 9024 6653 Web: www.rev-bikes.com

Price for the "Offroad" Kit (wheel with 1000W motor, 48V battery pack & charger, battery rack, controls and wiring) as seen here: $1295.00

SPECIAL SILICON CHIP READER OFFER:

Order this kit from Rev-Bikes before December 9 (for guaranteed pre-Christmas delivery) and they'll give you a huge discount, just for saying you saw the article in SILICON CHIP!
That's right: SILICON CHIP reader price is just $1150.00

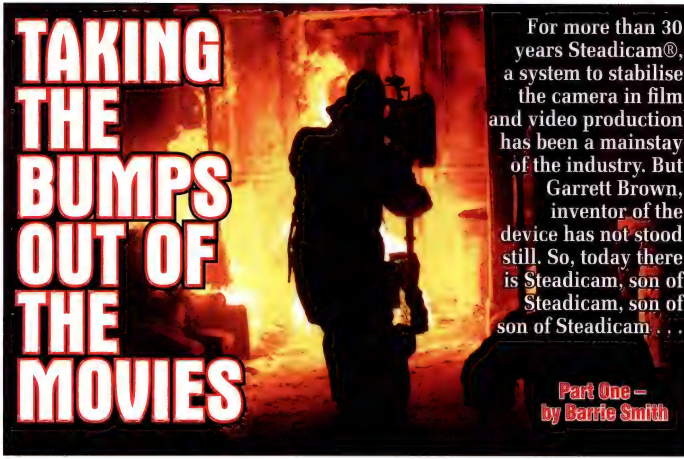
BUT WAIT, THERE'S MORE!

They'll also throw in a FREE set of lights with orders placed during November!

Many options and accessories are also available such as a Solar Kit which charges your battery while sitting in the sun. Price is around $500 (depends on voltage).

See www.rev-bikes.com for more details.

TAKING THE BUMPS OUT OF THE MOVIES



For more than 30 years Steadicam®, a system to stabilise the camera in film and video production has been a mainstay of the industry. But Garrett Brown, inventor of the device has not stood still. So, today there is Steadicam, son of Steadicam, son of son of Steadicam . . .

Part One – by Barrie Smith

In my early years as a TV commercial Director in the mid 50s, I well remember working with cameramen who had been in the industry during WW2 and before.

Some had been combat cameramen, others had shot feature films and documentaries.

The equipment they worked with was magnificently engineered but built like the proverbial battleship.

The mainstay camera of the time was the American-made 35mm Mitchell BNC, sound-proofed, carrying a 1000 foot magazine and fitted with an industrial strength viewing system that gave you two options.

One was to rack over the camera so you could preview and focus the scene through the lens — but not shoot; the other used a parallax-correctable viewfinder that fitted onto the side of the camera, so you could view the scene while you shot, while the lens' light path went direct to the film.

It usually took two men to carry and fit the Mitchell to a support base, usually a heavy duty tripod or a dolly.

The other camera that was usually used for location work was the German-made 35mm Arriflex, weighing only a few kilos, compact in size and driven by a small set of portable batteries.

Only the cameraman could view the scene while he photographed. This was the world's first mirror reflex motion picture camera and saw considerable use by German newsreel cameramen throughout WW2.

If a director wanted the camera to move during a shot he could only request a dolly or a crane shot, necessitating mounting a camera on a substantial, metal-built dolly or a wooden platform with rubber wheels called a western dolly — or a crane that could not only move the camera forward but up and down and laterally as well.

But to operate these devices you needed the manpower of the studio grips to push and manoeuvre them around.

A handheld shot was definitely not possible unless the cameraman was willing to use the Arri and fly blind, without the ability to view what the camera was photographing.

The zoom lens, as another way of changing the camera viewpoint did not come into general use for 35mm cinematography until the 1960s.

Then Garrett Brown, a native of Philadelphia, sat down and did some hard thinking.

Garrett's great idea

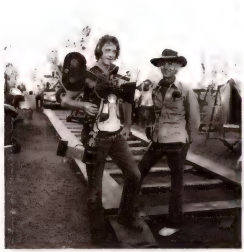
Beginning as a folk singer, he made an early entré into advertising as a copywriter. Next stop was to open a small film production company, using a Afrika Korps (Rommel-era) Arriflex, strapped to a 360kg dolly, shooting TV commercials.

Brown recalls in a 1972 interview that it "broke our hearts lugging this dolly around in pickup trucks … but I loved the moving camera."

Commercials with technical challenges interested him the most. On one occasion he put together a rig for an advert that allowed the camera to move freely through the rooms of a house.

Taking the idea further he spent a week locked up in a motel and built a series of gadgets to do this, traveling down a couple of unproductive roads and although he felt he could actually make stable shots, the gadgets were not 'manufacturable'.

An early approach was to use a length of plumbing pipe as a support, which was stable in all directions as



The younger Garrett Brown operated his Steadicam prototype for the first time on the feature film "Bound for Glory" in 1975. The director's first shot called for Brown to mix a complicated crane shot that began ten metres up in the air, descend, then he walked off with the Steadicam.

you moved around. Brown recalls that it "was clumsy and rolled a lot", but the footage shot with it looked surprisingly good.

Then Brown mounted the camera on his body. Next, he worked out how to balance the camera so that it was easily movable. He used some of the heaviest camera parts, such as the battery, as counterweights. Along the way he experimented with bungee cords and gyroscopes.

Brown went even further, building a body harness, moving the camera away from the operator's body and floating it, while maintaining a level point of view as it moved up and down.

At this point he had a working rig and was able to shoot TV ads with it, getting the agency guys to sign confidentiality agreements to keep details of the invention from leaking out.

It's worth noting that there is no gyroscope in the Steadicam.

Stabilising is achieved by shifting the camera's relation to the operator from being handheld to body-supported, augmented by the stabilising force of springs and pulleys in the arm that connects the camera to the body.

It was 1974 and Brown felt he had to make a move: he approached Panavision, whose people were "dying to see what the device looked like."

His demo visit to Panavision went badly: after showing a film he had made with the new invention, the Panavision people were keen to actually see the gear.

Brown asked them to sign a non-disclosure document to protect his design. The Panavision executives refused and that was the end of it.

However, the same day, Brown went to see Cinema Products Co. The President, Ed DiGiulio had no problem signing the non-disclosure.

As Brown recalls it "Within a day we had the bones of a contract and CP launched on building the Steadicam. The rest is history."

Australian cinematographer Kane Guglielmi operating a Steadicam, with the ability to view what he is shooting on a low-set LCD screen.

Panaglide

As a footnote to Panavision's interest in the device, some years later the company came out with Panaglide, as Brown describes it: "a nearly exact copy of Steadicam . . ." While he had offered them the device first, they stalled and then tried to do their own, spending a reputed four million dollars in their efforts.

"Funny thing was that none of their efforts were functional until they hid out in the scenery and photographed our prototypes and did it the same — part for part .... On being sued, they folded and became a licensee, and eventually just bought Steadicam gear from us."

It made its debut in the movie Bound for Glory (1976).

The view

However I may have wished that my 1950s cameramen could have shot hand-held, it's obvious to me now that the camera's weight was not the main obstacle to freeing it up.

At that time there was only one way that the operator could view the scene before the lens: with his eye stuck to the viewfinder! He was bound to the lens.

Brown explains that, aside from isolating the operator from the camera, he also realised it was not the only challenge: in his first Steadicam he ran a fibre optic cable from the camera viewfinder all the way up to the operator's eye.

At last, operator and camera could be remote from each other.

Today, the system relies on a video split or assist, with a portion of the camera's incoming light path diverted to a video sensor and the rest to the actual film frame or image sensor, in the case of a video camera.

These days, the cameraman and Director – and, sometimes unfortunately, the rest of the crew as well – can see each take of the action as it happens.

Most importantly, the Steadicam operator now has a small LCD screen mounted beneath his rig so he can see what he is shooting.

Steadicam Archer

(left): the top model, the Steadicam Ultra, able to support a 22kg film or video camera.

How it works

Users of digital still and video cameras have it easy! Stabilising of these (where fitted) is usually handled by steadying either the lens or the image sensor itself.

With the former, unwanted motion is detected by an angular velocity sensor and this information then controls and alters the angle of an element within the lens.

In the latter case, sensors detect motion or vibration and this information is used to move the image sensor (CCD or CMOS) itself, so that the incoming image is captured correctly.

When an operator holds a motion picture or broadcast camera and moves forward, movement of the body, arms and legs is transmitted to the camera. Steadicam seeks to counteract this.

Even when a cameraman stands still, it is still likely that unwanted movement is passed on to the camera. The problem lies in the human perception's ability to iron out bumps as we walk and talk; we just don't realise how shaky the camera's view actually is.

Garrett Brown's invention set out to isolate the camera from the cameraman and, in the process, dampen shocks and bumps.

The basic component in Steadicam is the vest, worn on the operator's upper body.

Attached to this vest is an articulated arm, consisting of three segments, with two lengths connected by a pivoting hinge; the vest and arm isolate the camera from the operator's body. This arm supports a sled or platform that holds the camera, viewfinder, battery etc.

Isolation is achieved with the arm, which is made up of a combination of springs, cables and pulleys.

It's an articulated support system

that parallels the operator's arm in any position and almost completely counteracts the weight of the sled/camera combination with a carefully calibrated spring force.

One of the Steadicam models (Master Series) is iso-elastic and thus completely counteracts the camera weight, being able to hold the latter's position in space when placed and released.

The arm and sled support the camera, etc on a central pole, so the main weight is far removed from the operator's body.

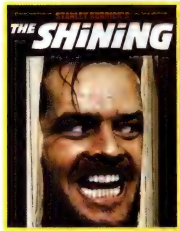
This arrangement can also be reversed so that camera is below, with the other items above, allowing the operator to shoot low angle shots.

Each arm segment resembles a parallelogram, being made up of two metal bars. As with any parallelogram, the metal bars will remain parallel with each other no matter where the arm is positioned.

The end blocks are secured to the ends of the parallel bars, so they will remain in the same position as the arm swings up and down.

A camera attached to one of the end pieces keeps pointing in approximately the same direction.

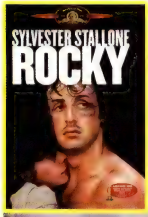
However another trick is used to maintain the sled in a level attitude: parallel metal bars in each arm are connected together with a spring system. The system is set up to exactly match the downward force of the sled's weight.

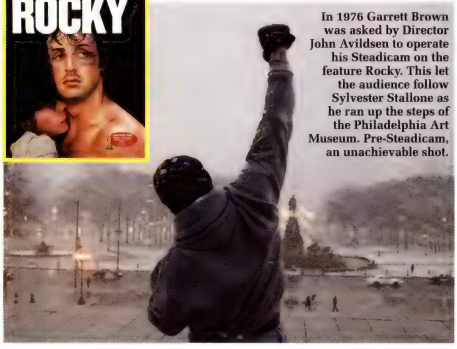


The Shining (1980), saw director Stanley Kubrick use Brown to capture a Steadicam shot to zip down the hallways of a haunted hotel, and another to follow Jack Nicholson through a snowy hedge maze.

So the arm and the camera sled will stay in the same position until the cameraman shifts the camera up and down. The springs can be adjusted to handle different camera weights and cushion bumps caused by operator movement.

The camera's weight is supported by the vest. The operator has only to aim the camera!





In 1976 Garrett Brown was asked by Director John Avildsen to operate his Steadicam on the feature Rocky. This let the audience follow Sylvester Stallone as he ran up the steps of the Philadelphia Art Museum. Pre-Steadicam, an unachievable shot.

Operating a Steadicam is one of the most difficult jobs on a movie set, but also one the most rewarding.

For a typical Steadicam shot, a cameraman must follow a preset path, while simultaneously adjusting the camera and avoiding any obstacles, all the while supporting more than 30kg or more of camera equipment.

Centres of gravity and mass

The centre of gravity is the point at which an object is in balance in all directions, and from which an object can be manipulated without adding any additional motion. Steadicam works by bringing the camera's centre of gravity, or centre of mass, from somewhere inside the camera to outside the camera and placing it where the operator can manipulate it.

The centre of mass (which differs to the centre of gravity, theoretically, although not in actual practice) is the point at which an object is in balance in all three dimensions, and this is what the gimbal is used for, as it precisely intersects the three axes and lets the operator control the camera from its centre of gravity.

This is the beauty of the Steadicam system. It's very simple. It achieves its results by using mass, balance and inertia.

The job requires a good deal of

physical stamina and technical skill, but it also calls for a good sense of shot composition. The Director plans the shot, but the Steadicam operator makes it happen.

The best technique for Steadicam operation depends entirely on the nature of the shot.

To film a simple conversation between two actors, an operator may try to replicate the even feel of a dolly shot, keeping the camera perfectly level and moving it slowly around the action.

For a "flying sequence" over low ground, the operator might intentionally tilt the camera from side to side, creating a soaring effect.

One of the most common uses of the Steadicam is to track actors as they move around obstacles or rough ground.

Typically, the operator will walk ahead of the actors, shooting them from the front as they walk and talk.

For this sort of shot, the operator may walk backwards through the scene, with the help of other crew members. He or she may also walk forward, with the camera pointing behind.

For these shots, and most any other shot, the director, the crew and the operator will all work together to figure out the best approach.

Most professional Steadicam operators work freelance, renting themselves as well as their equipment out as a complete package. When a scene in a film calls for a Steadicam shot, the filmmakers will select a Steadicam operator based on his or her past work.

Most established Steadicam operators are members of the Steadicam Operators Association (SOA).

In addition to representing hundreds of Steadicam operators, the SOA holds regular Steadicam training workshops. Tiffen, the company that manufactures Steadicams, also organises training sessions.

Steadicam operators have helped create some of the most memorable shots in film history.

In Rocky (1976), one of the first feature films to use Steadicams, operator Garrett Brown let the audience follow Sylvester Stallone as he ran up the steps of the Philadelphia Art Museum.

This shot, one of the most memorable in the movie, would have been nearly impossible before the Steadicam.

In The Shining (1980), director Stanley Kubrick used a Steadicam shot to zip down the hallways of a haunted hotel, and another to follow Jack Nicholson through a snowy hedge maze.

In the latter, Brown had to walk backwards, revealing the snow-covered ground. In order to conceal his own footsteps, he walked on stilts!

In addition to standard film models, there are Steadicams for lighter video cameras and there are specialised models such as Tango that take the principle even further.

The Tiffen Company has taken over from Cinema Products and makes Steadicams for the worldwide market.

In July this year, Brown and his associate Jerry Holway held courses in Steadicam operation in Australia. I took the opportunity to speak with both of them – more of this in part two.

Legal (and Illegal) Copies

There are a number of illegal copies of Steadicam being made in Asia and Europe (such as that shown here). I asked Brown what could he do about it? Now that the name is almost part of the language what action can you take? Are the patents still current?

Brown: "Most of the 40 or so copies in the world are legal... based on my original patent suit that expired in the mid '90s. We have a dozen or so patents on improvements and some Chinese rigs infringe a few of them. All we can do is go after them if they try to market the gear in the West. But the Steadicam trademark itself is vigorously protected. Wouldn't want it to become generic while I'm still upright and inventing new stuff!"

In July this year Garrett Brown and associate Jerry Holway travelled to Sydney to host a series of Steadicam courses.

Part Two

Seemingly unable to stop inventing more technology, Garrett Brown soon moved on from Steadicam and came up with ways of moving a camera above and across a sports field, or down into a pool as a diver descended and tracking with swimmers as they moved from one end of the pool to the other.

This and more in Steadicam Part Two, coming next month in SILICON CHIP.

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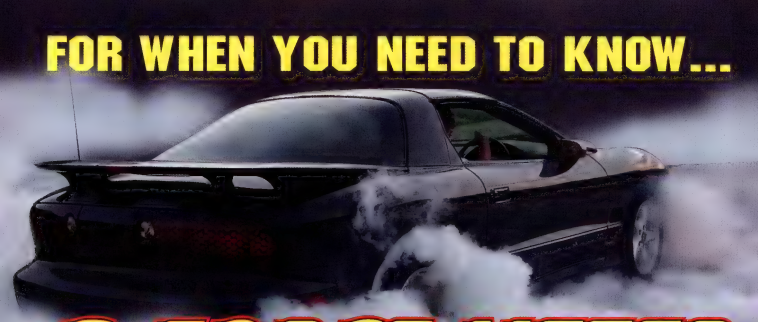


G-FORCE METER

Just what *are* the g forces involved in a balls-to-the-wall lap of Mt Panorama? This little beauty will tell you: instantaneous acceleration, braking, cornering; forwards, backwards, sideways . . . and it's battery operated and completely portable, so you can swap it from car to car!

Why would you want a g-force meter in your car? Good question. This project comes about because as soon as we published the Digital Spirit Level (August 2011) we had a number of readers contact us to ask "Can this be used as a g-force meter?". Your wish is our command!

We know they are fitted to some high-performance vehicles, such as the Nissan GTR, showing the instantaneous acceleration, braking and cornering forces.

These can be used to gauge vehicle and/or driver performance. The faster the car accelerates or corners, the higher the g-force. Ditto for braking – is the driver putting the vehicle under too much stress by braking too late or too hard?

And what about the driver him/herself? Throwing the car around a corner might look pretty spectacular but it's also pretty stressful on the driver (not to mention the car!).

Of course, you're unlikely to do a hot lap around Bathurst. But the g force meter can just as easily be used to save petrol and wear & tear and/or temper youthful exuberance by making your driving as smooth as possible.

G-force meters, more properly called accelerometers, measure force in a particular direction. If your car doesn't have one of these (and let's face it, you probably don't think it does), now you can easily add one!

Actually you might be surprised to find out that most modern cars do contain one or more accelerometers. For example, air-bag systems use them to detect accident severity and so decide whether to inflate the air-bags and if so, how fast.

The engine or body computer may also contain an accelerometer to detect when the vehicle is on a hill, in order to change how the transmission or engine behaves. But in most cases, there's no display to show you the readings – nor is there any way to capture the data.

Apart from automotive use, there are many other places where g force measurement would be handy. For example – a powerboat crashing over waves: you know you can really get thrown around . . . but just how much?

Or perhaps one of those heart-in-your-mouth thrill rides at theme parks and shows. Just what are the forces involved? (Actually you might be surprised at how low many of them are!)

But if you've ever tried to buy a commercial g-force meter (or accelerometer) you would know that for most people, they have been basically unaffordable. We've changed that with this little beauty!

On the level? Yes!

So this project is an adaptation of the Digital Spirit Level which was published in our August 2011 issue.

In fact, it uses the same MMA8451Q accelerometer IC and shares virtually

Design by Andrew Levido Words by Nicholas Vinen

all of the hardware with that project.

But the software has been changed so that, rather than reading out a tilt angle in degrees, it shows the forward/back or left/right acceleration in units relative to the earth's gravity (1g = 9.81N = 9.81m/s^2).

The new software places the MMA8451Q in a mode where it can make rapid readings but the range is limited from -2g to +2g for each axis.

Why not a greater range? Simple: if your vehicle experiences forces in excess of 2g, the limited range of the readout will be the least of your worries; such high g forces are usually only experienced during a prang (and a pretty bad one at that!).

For instance, the Bugatti Veyron, which is the world's fastest production car (top speed on the up side of 400km/h), can accelerate from a standing start to 100km/h in 2.4s. Measured maximum g-force? 1.55g.

Readings

At this point we should explain just what the readings on the Accelerometer display mean. Firstly, the reading indicates the experienced force which doesn't necessarily match the actual vehicle acceleration.

Say you are in a car accelerating at full throttle. Depending on how powerful the engine is (and how much the vehicle weighs), you will experience a sensation of being pressed back into the seat. This is due to Newton's third law of motion: "For every action there is an equal and opposite reaction". In this case the action is the car accelerating forwards and the reaction is you being pressing back into the seat.

Now consider the same car, parked facing up a hill. You will experience a similar sensation. In this case, it is the force of gravity pushing you back into the seat.

In these situations, the accelerometer will experience the same forces you do. So in both cases, it will report a "forward acceleration" - despite the fact that in the second example, the car isn't moving.

So why didn't we make it read zero in the second case? Firstly, the force being reported is real, so you could argue that the unit should respond to it.

Consider what happens if you accelerate up a hill; the engine must work harder than it would to accelerate at the same rate on level ground. So the fact that the accelerometer reading will be higher in that situation makes sense. Similarly, it will read lower when accelerating down a hill, which is gravity-assisted.

Secondly, to compensate for the effects of gravity would be surprisingly difficult. To disentangle the gravity and acceleration vectors, we would need a digital gyroscope (also available, using MEMS technology).

This could be integrated to keep track of the vehicle's orientation, compute the effect of gravity and thus eliminate it from the readings. But because a gyroscope measures instantaneous rotation (not tilt angle), calculating the gravity vector would still be a bit tricky, requiring an integration function.

In the end we decided that including the gravitational component in the

readings was both sensible and easy.

If you want to measure pure vehicle acceleration, you will need to do so on a flat surface.

Form factor

Besides the software, the other change compared to the Digital Spirit Level is the cheaper and simpler housing; a UB3 jiffy box.

Power is still from two AA alkaline cells but if you want to run it from 12V (eg, from a cigarette lighter socket), it's a simple matter to add an appropriate voltage regulator.

How it works

The circuit is built around the 3-axis MEMS accelerometer (IC1), PIC18LF14K22 microcontroller (IC2) and a four-digit LED 7-segment display (DISP1-4).

The g-force experienced is shown on the display with the first digit indicating the direction (F=forward, b=back, L=left, r=right) and the three remaining digits showing g-force in the range of 0.00-2.00g.

The MEMS accelerometer contains three micro-machined mechanical arms. They are at right-angles to each other and they each bend and deflect in response to force along one axis. By measuring the amount of deflection, the IC can measure the force it experiences.

The arms each form a capacitor with the surface they are mounted on and this capacitance changes as they deflect, because the distance between the capacitor "plates" is changing. These capacitance shifts change the frequency of an oscillator in the IC and the oscillation frequency is counted.

A mathematical formula can then be used to convert this frequency into an acceleration reading for that axis.

When the calibration button (S1) is pushed, IC2 reads the current measurement from the accelerometer and stores it in its internal flash memory.

From then on, this is used as the gravity reference vector. This is subtracted from subsequent readings, forming a difference vector which represents the acceleration of the vehicle. It is then split into forward-back and left-right components.

If either of these is higher than the currently displayed acceleration value, the display is updated with the new value and the five-second timer is reset.

If the timer expires, ie, the same peak value has been displayed for five seconds, the display is reset and it then shows the acceleration value for whichever of the two axes is currently experiencing the highest acceleration.

In a non-accelerating vehicle on a level surface, the reading will be close to zero.

Circuit description

The full circuit for the accelerometer is shown in Fig.1. The only change from the digital spirit level is that we have added a power switch, S2.

The digital spirit level was switched on by shaking and it automatically turned off with inactivity but since this unit may be used for long periods, a power switch was judged the more sensible approach.

The micro, IC2, drives the eight 7-segment display anodes directly from its outputs, via 4.7Ω current-

Force vs acceleration

In this article, we use the words "force" and "acceleration" interchangeably, even though we know they aren't the same thing.

Newton's second law of motion says: Force = Mass x Acceleration. So while the acceleration due to gravity (1g) is more or less constant, the force due to gravity depends on the mass of the object.

While this is a "g-force" meter, it actually reads acceleration. But it does so by measuring the force it experiences. Is that confusing or what?

We decided to risk the wrath of physicists everywhere and use these terms as people are familiar with them.

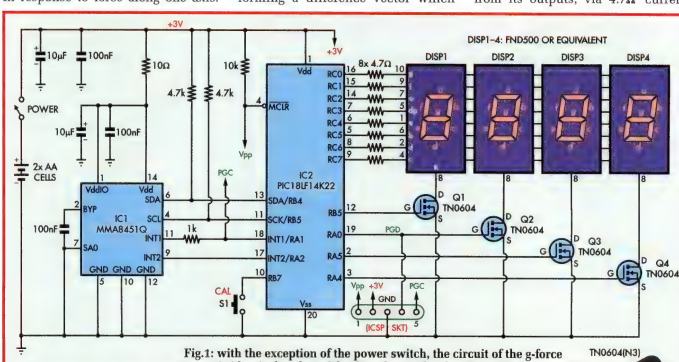
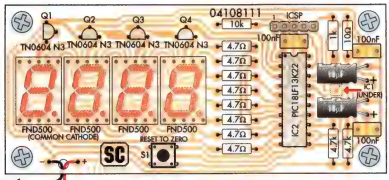
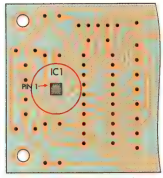


Fig.1: with the exception of the power switch, the circuit of the g-force meter is identical to that of the digital spirit level published in our August issue. For a full description of how the accelerometer chip operates, refer to that issue. Note that the software is quite different for this project.

TN0604(N3)

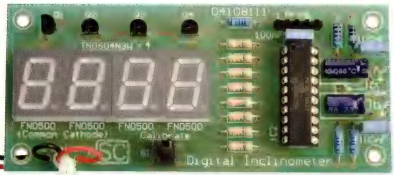
SC G-FORCE METER





(UNDERSIDE OF BOARD)

Fig.2: (above) the PCB component overlay, with the underside of the board at right showing the SMD accelerometer chip. A same-size top-side photo is below (only the SMD chip is on the underside).



limiting resistors. The display common cathodes are driven using four Mosfets, Q1-Q4. Their gate voltages are controlled by outputs RA0, RA4-5 and RB5 of IC2. These are special Mosfets which have a low on-resistance even with a low gate drive voltage.

This is important since the supply voltage is limited and any voltage losses across the Mosfets will reduce the display brightness.

Since the display is multiplexed, with each digit on 25% of the time and since the microcontroller outputs driving the anodes have limited current capability, we need as much brightness as we can get.

Communication with the accelerometer, IC1, is via I/O pins RB4-5 and PA1-2. RA1 and RA2 are connected to the interrupt pins of IC2 (INT1 and INT2 respectively) and these are used by IC2 to signal events and that acceleration data is ready to be read out from its internal buffers.

Commands and data are sent over the I²C bus with pins SDA (data) and SCL (clock). Each has a 4.7kΩ pull-up to VCC, as I²C utilises open-collector outputs to enable bus sharing.

The power supply for IC1 is smoothed with an RC filter consisting of a 10Ω resistor and 100nF and 10µF capacitors in parallel. It also has a separate filter capacitor connected to the BYP (bypass) pin, pin2.

For calibration, pushbutton switch S1 is connected between input RB7 of IC2 and ground. IC2 enables its internal weak pull-up current source on that pin so that when the button is pressed, the input state changes from high to low. It is debounced in software.

The whole circuit runs off a 3V battery consisting of two AA cells bypassed with a 10µF capacitor. IC1 also has a 100nF high-frequency bypass capacitor.

Construction

First mount is IC1, the accelerometer. This only comes in a small 16-pin QFN (quad-flat no-leads) package.

In fact, all MEMS accelerometers and gyroscopes seem to come in similar packages, presumably for compactness (they are frequently found in mobile phones).

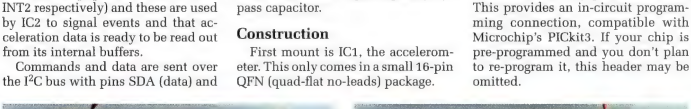
Because it has no leads, it's quite tricky to solder. In the Digital Spirit Level article, one particular method was recommended. We have also tried another method which worked quite well and this is described in the panel on p33. Follow those directions there to solder the IC.

Then flip the board over and install the resistors. We recommend the use of a digital multimeter to check the value of each before it is installed. Follow with the IC (a socket is optional), ensuring it goes in the right way around.

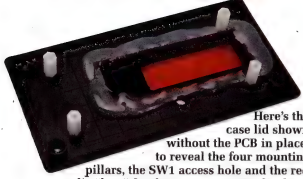
Next, fit the four 7-segment displays, again careful with polarity (the decimal point goes at lower-right in each case) and make sure they are neatly lined up and flat against the PCB before soldering them in place.

Solder the capacitors in next. Note that the two electrolytic types should be laid over on their sides. In each case the longer lead goes into the pad towards the bottom of the board. The four Mosfets can then be mounted, with their leads cranked out using small pliers, to suit the pad spacing on the PCB. They are static-sensitive so be careful in handling them.

Mount the 5-way pin header next. This provides an in-circuit programming connection, compatible with Microchip's PICkit3. If your chip is pre-programmed and you don't plan to re-program it, this header may be omitted.



The PCB "hangs" off the front panel by means of four 12mm spacers, as these two photos (one taken from top, one from the bottom) show. The pushbutton switch (SW1) is the only control which emerges through the panel.



Here's the case lid shown without the PCB in place, to reveal the four mounting pillars, the SW1 access hole and the red acrylic "lens" for the 7-segment LED displays.

Finally, solder the tactile pushbutton (S1) in place. Ensure it is pushed right down against the PCB before soldering. The button should be orientated so that its leads project out to the left and the right (this is really the only way it will fit as the pads aren't quite arranged in a square). When you are finished, its actuator shaft should be perpendicular to the PCB surface.

Testing it

Pass the battery wires up through the hole in the board and solder them to the appropriate pads. Double-check that the polarity is correct (there is no reverse polarity protection!). Tighten a small cable tie around the leads just above the hole that they pass through and trim it. Insert the cells and check that the unit is operating correctly.

If it is, the display will light up and read either "Fx.xx", "bx.xx", "Lx.xx" or "rx.xx", where xx.x is a number between 0.00 and 2.00. Hold the PCB vertically and press S1. The number shown should then be closer to zero. You can then change the reading by moving the board in, out and side-to-side. Remember that it has a five-second peak hold. Remove the cells from the holder.

If it didn't work, check the orientation of all polarised components (IC1, IC2, Q1-Q4 and the two electrolytic capacitors). Assuming they're OK, the most likely problem is that IC1 isn't soldered properly. Re-flow its pins using flux and solder wick, as described in the panel. Then try again.

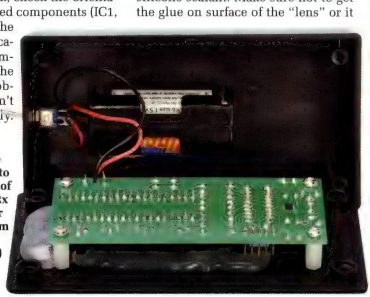
Housing it

Remove the lid from the UB3 jiffy box and attach a printout of the front panel (available from siliconchip.com.au) to use as a drilling/cutting template. Use a sharp knife to cut out the display area rectangle from the photocopy before attaching it. You can then use the same knife to (carefully!) etch the outline of the display into the lid.

Drill the five holes to 3mm where indicated. Also drill a series of holes around the inside of the outline for the display, then knock the panel out (side-cutters can be used to remove any remaining plastic sections keeping it in place). Use a large, flat file to carefully file the edges flat and to shape the cut-out to the etched outline. You may need to use needle files to finish the corners. Remove any "lip" formed in the process of filing with a sharp knife.

De-burr the holes then temporarily attach the PCB to the rear of the lid using the four 12mm tapped spacers and eight M3 machine screws, with the black screws on the outside. Check that the pushbutton is properly lined up with its hole and that it doesn't "stick" when pressed due to misalignment or the hole being slightly too small. Enlarge it if necessary.

Remove the board and place the acrylic sheet behind the cut-out and glue it in place. We used hot melt glue but you can also use neutral cure silicone sealant. Make sure not to get the glue on surface of the "lens" or it



Finally, the completed g-force meter opened up to show the method of assembly with a 2x AA battery holder glued to the bottom of the case and a power switch (S2) through the case side.

Parts list – g-force meter

1 PCB, code 04108111, 100 x 44mm *
1 tactile pushbutton momentary switch with 22mm actuator (S1) (Altronics S1119)
1 pushbutton cap to suit S1 (Altronics S1481)
1 SPST (or SPDT) miniature toggle switch (S2)
1 5-way 2.54mm pitch pin header
1 2 x AA battery holder
1 UB3 jiffy box
1 transparent red Acrylic or Perspex sheet, 60 x 25mm
4 M3 x 12mm tapped spacers
4 M3 x 6mm pan-head machine screws
4 M3 x 5/6mm black machine screws
1 small cable tie
1 60mm length foam-cored double-sided tape
hot melt glue or neutral cure silicone sealant

* see below

Semiconductors

1 MMA8451Q 3-axis accelerometer (IC1) *
1 PIC18LF14K22-I/P micro-controller programmed with 0410811C.hex (IC2) *
4 TN0604N3 Mosfets (Q1-Q4) *
4 FND500 7-segment LED displays or equivalent (Jaycar ZD1855, Altronics Z0190)

Capacitors

2 10µF 16V electrolytic
3 100nF MKT or monolithic ceramic

Resistors (0.25W, 1%)

1 10kΩ 2 4.7kΩ 1 1kΩ
1 10Ω 8 4.7Ω

SHORT FORM KIT

* A short-form kit consisting of:

1 **Printed Circuit Board (04108111)**
1 **MMA8451Q Accelerometer Chip**
1 **PRE-PROGRAMMED PIC18LF-14K22-I/P microcontroller**
4 **TN0604N3 Mosfets**

(IE, ALL THE HARD-TO-GET PARTS!)

is available direct from SILICON CHIP for only $44.50 plus $10 p&p. Contact details are on P102.

Soldering the QFN SMD IC

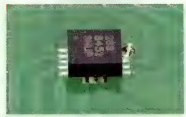
The procedure for soldering the QFN device, as detailed in the Inclinometer article, is (briefly) as follows: tin the pads, place the IC on top, line up its pads, then reflow the solder added earlier to form the joints between the PCB pads and the IC pads.

While this method works and doesn't require any special tools, we tried a different approach this time, which we think might be more reliable.

First, place a small amount of solder on one of the PCB pads. We started with the top-right pad; left-handers may prefer to start at the upper left. Then place the IC alongside its final position (but not on this pad) and check its orientation. Be very careful as it's difficult to remove once it's in place.

Then heat the solder on that pad and, using angled tweezers, slide the IC into position. Remove the heat and check the IC under a illuminated magnifying lamp to see whether its pads are lined up correctly on all sides. They are copper coloured and are just visible around the bottom edge of the chip; the PCB pads should be tinned and therefore look silver.

It's unlikely that the IC will be perfectly positioned on the first attempt, so re-heat the solder on that one pad and very gently



nudge the chip in the right direction (again using the tweezers). Check it again under a magnifying glass and repeat this procedure as many times as is necessary, until it is correctly positioned.

Note that boards with a solder mask can fool you; the solder mask isn't necessarily perfectly aligned with the pads themselves. See the photo above. We thought we had lined up the IC with the pads but we had instead lined it up with the holes in the solder mask layer – we fixed this (and the shorted pads!) after taking the photo.

Once the pads are properly lined up on all four sides, apply solder to the pad diagonally opposite the one you started with. Unless your soldering iron has a very fine tip, you will need to put a fair bit fo solder on the tip for it to bulge, then use gravity to flow it up against the corner junction formed by the the IC and the PCB.

You can then flow solder onto all the remaining pads using the same method (ignoring solder bridges for now). Then apply a thin layer of flux paste all around the edges.

Now place some solder wick flat on the PCB, as close to the IC as possible and heat it with your soldering iron. Once the flux starts to smoke, gently push it up against the edge of the IC. After a couple fo seconds, any excess solder will flow into the wick and also under the IC pads, filling the gap between it and the PCB. Wait a few seconds, then remove the wick and the soldering icon. It should leave just the right amount of solder on the pads.

You can then clean off any remaining flux with isopropyl alcohol, although if you used "no-clean" flux paste (usually a good idea) this isn't strictly necessary.

Our board worked first time after installing the IC using this method. If yours doesn't, add some more solder to each pad and re-flow them again to ensure that they are all properly connected.

Note that this method is very similar to that described for soldering fine-pitch SMD ICs such as TSSOP and QFP in the October 2009 issue ("How To Hand-Solder Very Small SMD ICs") and once you get the hang of it, it can be applied to a wide variety of SMDs.

will be damaged. Just flow it around the edges, as shown in the photo. Once the glue has set, trim away any areas that interfere with the corner posts, programming header or any other tall components.

Then drill a small hole in the box itself, for the toggle switch. You can put it anywhere you like; we opted for the left side. Don't put it too close to the lid.

Cut the red battery wire about 5cm from where it leaves the PCB, strip both ends and solder them across one pole of the chassis-mount toggle switch (ie, one to the centre and one to an adjacent tab). Re-insert the two AA cells and check that the switch works.

You can then re-attach the PCB to the rear of the lid and push on the cap for switch S1 (push it hard, so it won't come off easily). Install the switch in the box and do up the nut tight. Then peel the protective coating off the strip of double-sided foam-core tape, press it onto the back of the battery holder and stick the battery holder in a convenient location in the case (in the middle is best). Make sure it's stuck down well.

It's then just a matter of screwing the lid on the box and (if provided) pushing the rubber caps over the screw holes to hide them.

All that's left is to figure out how to stick the unit to your dashboard (or wherever you want to put it). You can use double-sided tape or BluTak (which can work surprisingly well, depending on the other surface).

But be careful because both are likely to leave residue on the dashboard which may be hard to remove. If you have an obsolete or broken GPS unit, you could re-use its suction cup mount for this purpose.

Wherever it is mounted, make sure it doesn't interfere with your field of vision or block the visibility of any important instruments (eg, speedometer).

Calibrating it

You will need to be parked on a level surface for proper calibration. If you have access to a poured concrete parking lot or garage floor, that is probably the best option (although it may have shifted since it was poured).

Park the car on a flat surface, turn the accelerometer on and press the calibrate button. The display should then read close to zero.

It will then remember the calibration setting even after it is switched off. It only needs to be re-calibrated if the mounting arrangement is changed.

To use it, just switch it on and glance at it after a manoeuvre to see the peak acceleration.

Don't be distracted by it and remember to keep your eyes on the road!

You can interpret the readings as follows:

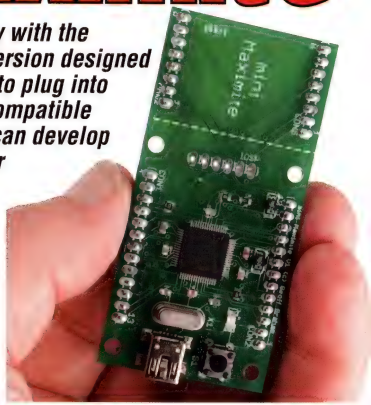
0.00-0.20g:	gentle acceleration/braking/cornering or gentle slope
0.20-0.35g:	moderate acceleration/braking/cornering or moderate to steep slope
0.35-0.60g:	hard acceleration/braking/cornering or very steep slope
0.60-0.80g:	racing
0.80-1.00g:	super-car territory
1.00g+:	extreme manoeuvres/collision

SC

The miniMaximite

A few months ago we described the Maximite, a small computer running the BASIC programming language. It could be used for many tasks and it was enthusiastically adopted by our readers.

We now add to the Maximite family with the miniMaximite; a small, low-cost version designed for use as an intelligent controller to plug into your creation. It is fully software compatible with the original Maximite so you can develop and test your program on the larger version, then transfer it to the miniMaximite when you are ready to screw the covers down.



By Geoff Graham

The Maximite computer, described in SILICON CHIP in March, April and May of this year has proved to be an unprecedented hit. By now over a thousand Maximites of various types have been built by enthusiastic readers.

Altronics has struggled for months to keep up with demand for kits, with each production run being sold out even before it was ready for sale.

The urge to play with the Maximite was so strong that it led many constructors to make their own PCBs or load the firmware onto Microchip evaluation boards or wire up their own breadboards.

The demand has also led to a growing Maximite ecosystem which even includes a number of Maximite clones (with approval, of course) from Dontronics (**www.dontronics.com**).

You can tell that you are popular when companies clone your creation; after all it happened to IBM with the PC clones, so why not SILICON CHIP?

Other companies have developed plug in boards and other accessories. For a full list of Maximite resources see the panel on page 38.

The readers who embraced the Maximite fell into one of three broad categories: they wanted to build a small computer and learn programming, or they wanted to use the Maximite to control something such as a home automation system. The final group just wanted to revisit the nostalgic days of yore when the Tandy TRS-80 and Commodore 64 dominated the personal computer landscape.

The miniMaximite described in this project is designed for the middle category of readers – those who want to embed the Maximite in a larger system as an intelligent controller.

Because the miniMaximite is 100% software compatible with its larger cousin you can develop your program on the full Maximite and when you are ready, copy the program to the miniMaximite and plug it into your circuit.

The "original" Maximite

Just to recap for readers who missed the Maximite articles – the Maximite is a small computer running a full featured BASIC interpreter including floating point numbers, string handling, arrays and much more.

The Maximite features a built-in VGA or composite video output and input from a standard IBM PS/2-compatible keyboard. It also has a USB interface for communicating with your PC and loading new versions of the firmware.

All you need to do is plug in a monitor, keyboard and 9V power pack and you are immediately ready to start writing your own program. You can type it in, test it and then

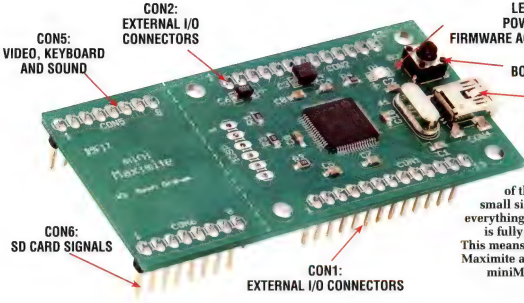


Fig.1: enlarged significantly for clarity (actual PCB size is 78 x 38mm), this shows the main features of the miniMaximite. Despite its small size, the miniMaximite can do everything its larger cousin can do and is fully software compatible with it. This means that you can develop on the Maximite and move you program to the miniMaximite when you are ready.

save it to the built in SD card interface, all on the Maximite without the intervention of a larger computer such as a PC.

The Maximite also has also 20 input/output lines which can be independently configured as analog inputs, digital inputs or digital outputs. You can measure voltage, frequencies, detect switch closure etc and respond by turning on lights, closing relays etc – all under control of your BASIC program

All of this is accomplished using a single low-cost chip!

The miniMaximite

The idea behind the miniMaximite is simple: to shrink the Maximite down to the size of a large postage stamp while keeping it 100% compatible with the larger version in its external I/O capabilities and programming language.

The only items that the miniMaximite is missing are the connectors for the VGA, keyboard, sound and SD card. You can add them to the miniMaximite if you wish; the signals are brought out onto header pins. But we expect that usually, the miniMaximite will be driving an LCD or indicator LEDs and using pushbuttons for inputs.

For this reason you should not think of the miniMaximite as a replacement for the full sized Maximite. It is a minimalist version designed to add intelligence to your next creation.

In fact, you should have both Maximites: develop your program on the full Maximite and when you are ready, copy the program to the miniMaximite embedded in your circuit.

The best part is that they're cheap enough to enable you to do this!

A quick tour

The best way to describe the miniMaximite is to take a tour of the assembled PCB with the aid of Fig.1. It could also help to refer to the articles describing the full-size Maximite.

The first items to note are CON1 and CON2. These are the external I/O connectors and each I/O pin can be configured to measure voltages, frequency, contact closures and more. They can also be configured as outputs to control relays, LEDs and drive other devices.

These two connectors have the same pinouts and capabilities as CON8 (the external I/O connector) in the full sized Maximite and use the same BASIC commands to control them. The connectors on the miniMaximite are positioned so that they can be plugged into a breadboard or strip board for prototyping and small-scale assemblies. You can also convert them to the standard Maximite 26 pin IDC cable using two connectors - this is described later.

LED1 is the power indicator and it will illuminate when the firmware has passed its tests and the unit is operating correctly. It also flashes when the miniMaximite is ready to receive a firmware update.

CON4 is a mini-USB connector for linking the miniMaximite to a normal personal computer. You can then edit and download programs to the miniMaximite just the same as you could on the larger Maximite.

If you hold down the pushbutton switch (S1) when power is applied, the Maximite will enter the bootload mode. In this mode it changes how the USB port appears to the personal computer (it emulates a HID device) and can receive software updates from the PC.

The Maximite: kits are available from Altronics.

In case you missed it . . .

Here's the Maximite Computer, as published in the March, April and May 2011 issues of Silicon Chip.

It's created an enormous amount of interest since publication with more than 1000 kits sold – and it's even spawned its own websites and special interest groups.

The new miniMaximite is functionally identical to the original but is intended for those who wish to embed it in other projects.

CON5 and CON6 are the header pins that carry the signals for the missing video, keyboard and SD card connectors. If you need any of these capabilities you can wire these pins to a standard connector, however we expect that most constructors would prefer to use the full-sized Maximite if they want these features.

The PCB is designed so that you can cut it on the dotted line and remove the extraneous headers resulting in a neat, minimalist PCB that can easily plug into a motherboard inside your creation.

New firmware

Astute readers will have already noticed that the miniMaximite does not include an SD card for program storage and as well, we encourage readers to cut off the headers carrying these signals.

So how does the miniMaximite save and run a program when it is in an embedded system? The answer is a new version of the Maximite firmware (version 2.7) that uses some of the internal flash memory of the PIC32 as a virtual disk drive.

This internal flash drive has a capacity of 256KB (enough for many programs) and all the commands that you use to store and load files on an SD card will work equally well on the internal flash drive. There are only two exceptions: you can have just one file open at a time and you cannot create directories.

Using the new firmware the internal flash drive is designated drive A: and the SD card (if connected) will appear as drive B:. These prefixes work the same as in DOS or Windows.

So, for example, you can use:

```
SAVE "A:TST.BAS" ' save to internal flash
```

or

```
SAVE "B:TST.BAS" ' save to the SD card
```

When the firmware is started, drive B: (the SD card) will be the default, even though there is no card detected in the connector. This is to maintain complete compatibility with earlier versions of the Maximite firmware.

You can easily change the default drive to the internal flash drive by using the command DRIVE "A:" and subsequently return the default to the SD card with DRIVE "B:".

Setting the default drive means that you do not need to use the prefixes A: or B: to specify the drive. For example, the following two program fragments will work the same:

```
10 OPEN "A:DATA.TXT" FOR INPUT AS #1
```

or

```
10 DRIVE "A:"
20 OPEN "DATA.TXT" FOR INPUT AS #1
```

On power up, the firmware will first search drive A: for the file "AUTORUN.BAS" and if found, execute that program immediately. If the file was not found on A: the search will be repeated on drive B: (the SD card, if connected) and the process repeated.

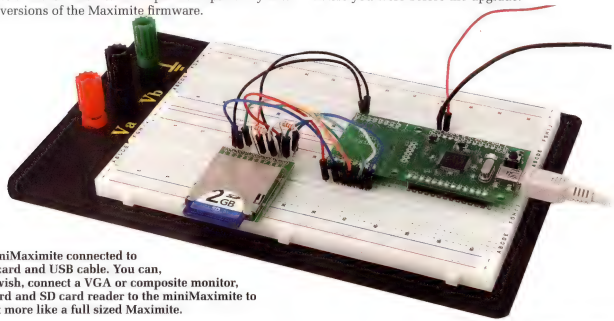
Normally, when using the miniMaximite as an embedded controller, your program will be held in "AUTORUN.BAS" saved to the internal flash drive (A:) so that it will be automatically run when power is applied.

Just before leaving this subject, it is worth reflecting on what this means. The Maximite was already a very capable computer running a powerful high-level language and now it has the equivalent of a flash memory card built in. And all this in a chip mounted on a module just 38 x 55mm in size. Amazing!

For the "big" Maximite too!

The new version of the firmware is not exclusive to the miniMaximite. It can also be loaded onto the full-sized Maximite and in fact we recommend that you do this as the latest version contains numerous bug fixes and improvements and runs faster than earlier versions.

You do not have to modify your Maximite; just load the firmware using the program supplied with the update. This process is described later in this article and is quite easy to do. If for some reason you do not like the new version, you can always load the old version and revert to exactly where you were before the upgrade.



The miniMaximite connected to an SD card and USB cable. You can, if you wish, connect a VGA or composite monitor, keyboard and SD card reader to the miniMaximite to make it more like a full sized Maximite.

One side benefit of using the internal flash memory for data storage is that it is faster than reading from and writing to the SD card. It is also handy for holding programs that need to be independent of the particular SD card that is inserted (for example, a menu program).

For the people who remember the Tandy TRS-80 or Commodore 64 this is the equivalent of attaching what was then a very expensive 5¼ inch floppy drive to your computer. However this time you don't need a screwdriver (and deep pockets!), it is done with a simple firmware upgrade that costs nothing!

XModem protocol

The astute reader will not be satisfied yet. How do you get files on and off this internal drive? It is not as if you can plug the PIC32 chip into your SD card reader!

This is why we also implemented the XModem protocol on the Maximite. This is a venerable standard dating from the 1970s and is used for copying files over a serial link – in this case, over the USB link to your PC.

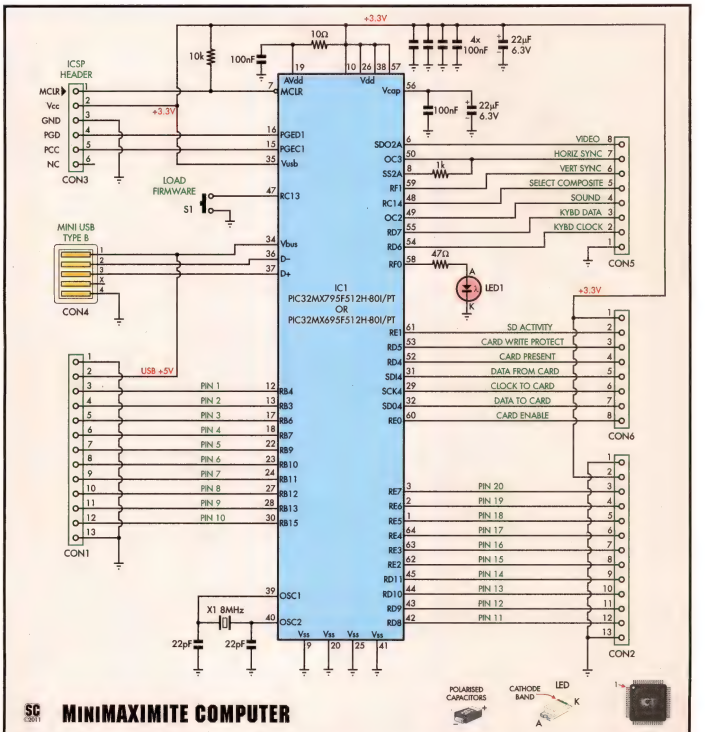


Fig.2: the full schematic for the miniMaximite. It is dominated by the microcontroller which is the only active device on the board. Power is externally supplied and should be in the range of 2.3 to 3.6V, which means that the miniMaximite could even be powered from a couple of alkaline or NiMH cells.

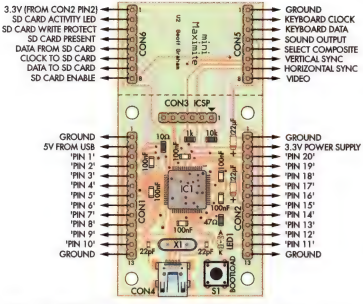


Fig.3: the PCB component overlay. It is largely surface-mount devices (SMDs) so you'll need to be adept at soldering these. The technique was featured in "how to" articles in the March 2008 and January 2005 issues of SILICON CHIP.

To copy a file to the Maximite run the following command on the Maximite:

XMODEM RECEIVE "filename"

Then, on your PC, run a terminal emulation program that supports the XModem protocol (we recommend Terra Term for Windows) and tell it to send the file using XModem. The file will be transferred over the USB and saved on the Maximite using the file name specified in the command (ie, "filename").

To copy a file from the Maximite and save it on your PC use the reverse command:

XMODEM SEND "filename"

On your PC instruct your terminal emulator to use the XModem receive protocol to save the file on your PC.

The circuit

The circuit of the miniMaximite is shown in Fig 2. It is very simple as nearly everything happens inside the very capable PIC32 microcontroller.

At the bottom of the schematic are CON1 and CON2 which are the external I/O connectors carrying 20 I/O pins. The detailed signal allocation for these connectors is shown in Fig.3 and you should refer to this diagram when you are designing a circuit for the miniMaximite to plug into.

Continuing around the PIC32 microcontroller in a clockwise direction, S1 is the pushbutton switch for initiating an update of the firmware. Inside the PIC32 a pullup resistor on the input for the switch is enabled. So, when the button is pressed the input is pulled low.

CON3 is a PICkit 3 compatible programming connector. You would only need this if you are building your own miniMaximite with a blank chip. If you purchase the miniMaximite chip as part of a kit or from SILICON CHIP the chip will be pre-programmed for you and you can ignore this connector.

X1 is the 8MHz crystal providing the internal clock and timing for the PIC32. Within the chip this frequency is divided by two them multiplied by 20 to give the main CPU clock of 80MHz. This clock is then further divided to give the baud rates for the serial interface, timing for the PAUSE command and timing for the internal real time clock maintained by MMBasic.

CON4 is the mini-USB connector which is used for downloading programs and firmware updates. One of the great features of the PIC32 is that all of the hardware necessary to drive the USB bus is integrated within the chip. All we need to do is wire the connector directly to the chip.

At the top of the PIC32 are a number of capacitors for filtering the supply voltages to the chip. Two connect to Vcap, which is the internal 1.8V regulator output supplying the MIPS CPU core. The 10Ω resistor and 100nF capacitor provide filtering for the analog portions of the chip (ie, the voltage measuring circuitry).

The remaining high-value capacitors provide filtering for the 3.3V supply to the chip. The 100nF capacitors are placed very close to the supply pins to provide optimal bypassing as larger tracks have more parasitic inductance.

On the top right hand side of the chip are CON5 and CON6. These carry the signals for the missing connectors (if you wish to implement them). CON5 carries the signals for the VGA or composite display, keyboard and sound while CON6 carries the signals for an SD card connector.

Construction

The miniMaximite mostly uses surface-mounted components. This was a deliberate design decision to reduce the PCB to practical proportions. After all, there are only 17 surface-mounted components so it is not a complicated board.

Many readers might think that dealing with these small components is too hard but that is wrong. It requires a different technique, that's all. You do not need complicated equipment, just your soldering iron and some patience.

All the prototypes were hand soldered and if you look closely at the photographs you will see that the result is excellent (nobody can accuse us of being modest).

We have described how to solder these devices many times in the past (eg, October 2009, March 2008 and January 2005 issues)

At a glance . . .

Processor:	PIC32MX795F512H-80I/PT (or PIC32MX695F512H-80I/PT)
Clock speed:	80MHz
RAM:	128K (internal)
Software:	MMBasic (similar to Microsoft BASIC)
I/O pins:	20, individually configurable
Video output:	Monochrome standard VGA or composite video
Audio:	500mV for amplifier, sound card, etc, or hi-z speaker
Interfaces:	USB 2.0 and IBM keyboard
Power supply:	2.3-3.6V DC @ (125mA plus peripherals)
Size & weight:	78 x 38 x 10mm; 15g

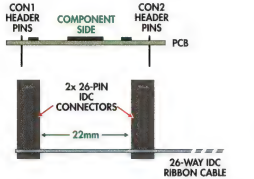


Fig 4. If you want to use the miniMaximite with an expansion unit that uses the full sized Maximite's 26 pin IDC connector you should build this cable. It will convert the header pins to a cable that is compatible with a cable plugged into the full sized Maximite

and we won't repeat that here.

The important factor is that, in addition to your temperature controlled soldering iron, you need to gather together just a few tools (all of these are available from the usual suspects, eg Jaycar, Altronics, element14, etc):

- A good liquid flux designed for SMD work.
- Fine tipped tweezers.
- A x3 magnifying loupe (or x10 if your eyes are not that good).

The important factor is the flux. Use plenty of it before you apply the soldering iron and the solder will flow quickly and easily. It makes your life much easier so don't spare it.

If you are new to soldering SMD devices you can watch an excellent tutorial on this subject at: **http://store.curiousinventor.com/guides/Surface_Mount_Soldering/101**

You should start construction with the microcontroller. As usual solder one corner pin and after checking the chip's alignment and orientation solder the opposite pin. You can then move around the chip soldering the other pins. Use plenty of flux and, to reduce the chance of creating a solder bridge, use only a little solder on your iron's tip. If you do get a bridge ignore it and carry on as you can come back later with solder wick to remove it.

Parts List - MiniMAXIMITE

1 PCB, code 07111111, 78mm x 38mm*
1 8MHz HC49 crystal (through hole mounting)
1 mini USB B socket, surface mount (Altronics P1308)
1 micro tactile push-button switch (through hole mount)
Pin header strips as needed
(at least 2 x 13 pin header strips will be required)

Semiconductors (Surface Mount)

1 Pre-programmed PIC32MX695F512H-80I/PT or PIC32MX795F512H-80I/PT microcontroller (IC1)*
1 Green LED (1206 package)

Capacitors (Surface Mount)

2 22µF 6.3V ***low ESR*** Tantalum (EIA 3216 package) or 10µF 6.3V X5R/X7R ceramic (3216 package)
6 100nF X7R ceramic (0805 package)
2 22pF ceramic (0805 package)

* see page 43

Resistors (Surface Mount, 0805 package)

1 10kΩ 1 1kΩ 1 47Ω 1 10Ω

The remainder of the components are easy enough. You should tack solder the component on one end and then properly solder the other end. Finally return to the first end and complete the solder joint properly.

Component identification

The PCB has the positive side of the polarised components marked with a large + symbol. That is the easy part but discovering the polarity of the components themselves can be a challenge.

SMD Tantalum capacitors have a stripe identifying the *positive* end, the opposite of electrolytic capacitors. If you are unsure of your capacitors you can measure their resistance with a multimeter: you will get a higher resistance when your multimeter's positive lead is on the capacitor's positive side.

The LED should have a small dot or green stripe marking the cathode (negative) but that is not guaranteed. It is best to use the diode test function on your multimeter to

Flash endurance

All flash memory, including that used in SD cards, has a limited endurance to erase/write cycles and when that limit is reached you can expect the flash memory to start producing errors.

The flash memory used inside the PIC32 has a specified endurance of 1000 erase/write cycles for each block of memory (4K bytes) which is typical for this type of memory.

While that might sound low it is not a real problem due to the way that MMBasic uses the memory.

When writing to the internal flash drive A:, MMBasic will spread the erase/writes evenly over the free blocks of flash memory.

The result is that if the drive was half full you could edit and re-save a typical program file every day of every year (including Christmas day!) for 87 years and still not reach the endurance limit.

Incidentally, an erase/write cycle occurs when you delete a file, overwrite a file or rename a file. A read has no effect on endurance so you can load a program or read a file as many times as you like.

This 87-year lifetime will be reduced if the drive has less free space or if the files are much larger than 4K (because there are less free blocks to share the erase/write cycles).

But even with the drive 75% full you could still edit/save an 8K file at the same rate for upwards of 20 years.

You do need to be careful with data files created within a MMBasic program as they can be created and erased very quickly (for example once a second) and if you write a program to do that you would quickly wear out the flash memory.

But you can expect a very long life if you keep erase/writes to a reasonable number.

So, the message is: Leave some free space on the drive and restrict erase/writes to an average of once or twice a day and you will never wear out the flash memory.

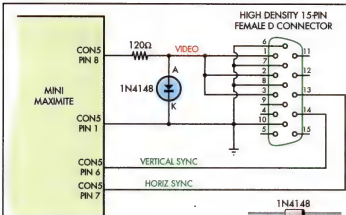


Fig.5: this circuit should be used if you need to connect a VGA monitor to the miniMaximite.

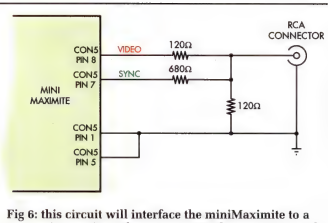


Fig 6: this circuit will interface the miniMaximite to a composite monitor. The output is 625 lines at 50Hz and will suit any TV set that is PAL-compatible

make sure. When the LED lights up the positive lead of your multimeter will be on the anode (positive) side of the component.

The larger components (USB connector, pushbutton switch and the crystal) should be the last to be mounted.

The USB connector is also surface mount but it is easy to solder because it has two small locating pins on the underside which match two holes in the PCB. This will keep it steady while you solder the mounting lugs and signal pins.

The crystal should be the last component to be mounted as when it is in place, it will prevent soldering the signal pins on the USB connector. When you solder its leads leave the body of the crystal sitting about a millimetre above the PC board. This will make sure that its metal case does not contact the tracks that run underneath if the PCB solder resist coating is damaged.

If you sourced your own parts to build the miniMaximite you will need to install a header at CON3 (the 6-pin header marked on the PCB as ICSP) and program the chip using a programmer such as the PICkit 3. The hex file is available on the SILICON CHIP website.

If your miniMaximite came pre-assembled or as part of a kit, you can skip this step as the supplier should have programmed it for you. The chips are also available pre-programmed from SILICON CHIP, along with the PCB. See the panel at the end of this article.

Testing

Testing the miniMaximite involves connecting 3.3V to CON2 (see below for the details) and checking that the LED lights up. This is only illuminated after the firmware has initialised everything and is ready to run a program. So, if the LED comes on, you can be sure that your miniMaximite is running. Conversely, if it does not illuminate you will have some fault-finding to do.

In this case you should first check that your power has the correct voltage and polarity. If you have an oscilloscope, check that there is 8MHz on both leads of the crystal.

Check that all the capacitors are in place; they are critical and a missing capacitor could easily prevent the processor from starting up. A common issue is not using a low ESR capacitor for C3, the 22µF capacitor connected to pin 56 of the PIC32 (see the box below on this subject).

Also check the LED and the 47Ω resistor as a faulty soldering joint or polarity could be the simple reason why the LED is not coming on.

The final check is to examine IC1 for shorts or defects in soldering. This will require a high-powered magnifying glass (or jeweller's loupe) and you will need to carefully check each pin. Again, in this case, solder wick and flux paste are your best friends!

Upgrading the firmware

Once your Maximite is running, you will be able to update the firmware via the USB interface using a Windows PC. This applies to either the miniMaximite or full-sized Maximite. The process is quite painless and provides you with the latest and best firmware.

The current version of the firmware is on the SILICON CHIP website but later you can also check if there is a more recent version on the Author's website: **http://geoffg.net/maximite.html#Downloads**

When you download the zip file for the upgrade you will find that it includes a program called BootLoader.exe. This program needs to be installed on your PC and this process is described in the instructions that also come with the upgrade.

Issues with the tantalum capacitors

If your Maximite (mini or full sized) does not start up the problem could be caused by the 22µF capacitor connected to pin 56 (Vcap) of the PIC32.

A reliable indicator of this fault is that the power LED does not come on and the Maximite will draw very little current (normal consumption is about 125mA).

This capacitor must be a low ESR Tantalum type and the PIC32 is very sensitive to its characteristics. If you suspect that it is causing trouble, try replacing it or paralleling it with a higher value and/or a higher working voltage (both of these will generally improve the ESR). Also try replacing it with another brand.

Some readers have had success by wiring another Tantalum capacitor (22 or 47µF) from pin 56 of the PIC32 to the 3.3V supply.

It is not certain why this would work but it is worth a try.

To start the upgrade process hold down the button S1 (marked bootload on the PCB) while you apply power. The LED will rapidly flash to show that it is in the upgrade mode. Connect the Maximite to your PC via USB and run the BootLoad.exe program.

In the program click on the "Load Hex File" button and navigate to where the upgrade file is on your PC (the new firmware will have the extension ".hex"). When you have loaded the hex file you can click on the "Program Device" button and the flash memory in your Maximite will be erased, programmed and verified.

Once this has completed the power LED will recommence flashing but at a slower rate. Cycle the power and the Maximite will now start up with the new version.

When upgrading the firmware, you need to be aware that the process will also erase the virtual disk (drive A:) in the PIC32's flash memory – so make sure that you first copy anything that needs saving.

Connecting it up

The miniMaximite needs a supply voltage of 2.3V to 3.6V with a normal running voltage of 3.3V. This wide voltage range means that the miniMaximite *could* even be powered from a couple of alkaline or NiMH cells. Bear in mind that the current draw is typically 125mA plus any current that might be drawn from the external I/O pins.

Pin 1 of CON2 is the negative (ground) and pin 2 of the same connector is the positive supply voltage. The corresponding pin in the full sized Maximite is the 3.3V output but in the miniMaximite this pin is used to power the device.

Pin 2 on CON1 corresponds to the 5V output on the full-sized Maximite. In the miniMaximite this pin carries the +5V from the USB connector (assuming that it is plugged into a host computer) and is handy if you wish to power your circuit from USB.

If you also want to power the miniMaximite from the same source you will need to provide a low dropout 3.3V regulator on your main circuit board and feed that voltage back to pin 2 of CON2.

The other pins on CON1 and CON2 are the external I/O signals that you can manipulate from within your BASIC program. For example, the following program will flash a LED connected to the line referred to as pin 12 in MMBasic (pin 11 of CON2) at 1Hz.

```
10 SETPIN 12, 8
20 PIN(12) = 1
30 PAUSE 500
40 PIN(12) = 0
50 PAUSE 500
60 GOTO 20
```

If you want to connect the miniMaximite to an expansion board or device that was designed to plug into CON8 (the external I/O connector) in the full sized Maximite, you will need to make up an adaptor cable. This cable is simple to construct using two 26-way IDC connectors.

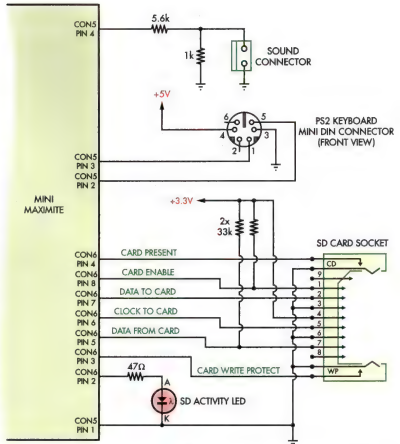


Fig 7. If you want to connect a keyboard, SD card or use the sound output this is the wiring diagram that you will need. Most peripherals do not need any additional components; it is just a case of wiring the header pins to the appropriate connectors.

The header pins for CON1 plug into the top row of pins of the first IDC connector (the uneven pin numbers) and the header pins for CON2 plug into the bottom row of pins (even pin numbers) of the second connector (see Fig.4).

The result is a cable that is compatible with a cable plugged into the full sized Maximite (with the exception of the pins carrying 3.3V and 5V as described above).

Video, keyboard and SD card

You can, if you wish, connect a VGA or composite monitor, keyboard and SD card reader to the miniMaximite to make it more like a full-sized Maximite.

If you refer to Fig.3, you can easily identify the signals available on these connectors. Fig.5 illustrates how you can connect up a VGA monitor while Fig.6 shows how to connect a composite monitor (eg, a TV). Fig.7 shows the wiring for the sound, keyboard and SD card connectors.

If you do have a video monitor connected, you will notice that the display will blank while MMBasic is writing to the internal flash drive (A:). This is because the firmware must turn off the DMA (which drives the video) to avoid corrupting the flash memory while it is being reprogrammed.

With all peripherals connected, the miniMaximite will run exactly the same as the full-sized Maximite – although, as we said earlier, this is not the intended purpose of the miniMaximite and we expect that most constructors will cut off the PCB section holding CON5 and CON6.

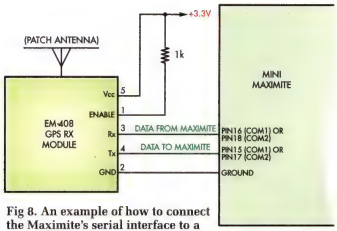


Fig 8. An example of how to connect the Maximite's serial interface to a device that uses a serial interface with TTL voltage levels. The "MMBasic Library" on the Author's web site (see the box "Maximite Resources") has an example program that will read and decode the data stream.

Communication capabilities

One of the most requested features for the Maximite was to communicate with other devices using serial, I²C and SPI protocols. These protocols are used to interface with a variety of devices and chips ranging from GPS receivers through memory chips to speech synthesisers.

These protocols are doubly important for a "plug in chip" styled device like the miniMaximite as it will need to cooperate with a variety of other chips in an embedded system.

So, it should come as no surprise that we have implemented these protocols in the latest versions of the firmware. And, just to emphasise the point, this firmware can be loaded onto the full sized Maximite so it too can communicate to these devices.

Serial interface

There are two serial interfaces available, labelled COM1 and COM2. The syntax and method of using them is compatible with Microsoft BASIC (as is most of MMBasic) so if you are familiar with that language you can jump right in.

When enabled, COM1 will take over pins 15 and 16 on the Maximite's external I/O connector.

This overrides the SETPIN and PIN commands which normally control these I/O pins.

Pin 15 becomes the receive line for COM1 (input to the Maximite) while pin 16 becomes the transmit line (the data is sent from the Maximite to the external device). Similarly, when COM2 is enabled it will take control of pins 19 (receive data) and 20 (transmit data).

The data is logic high when the output/input voltage is high. This is the standard when connecting serial devices that use standard TTL logic levels and it makes it easy to connect to another device such as a GPS module as illustrated in Fig.8.

The "MMBasic Library" on the Author's web site (see the box "Maximite Resources") has an example program that will read the data stream from the GPS module and extract information such as the current latitude and longitude.

To interface to a personal computer or a modem, you need to convert the signal levels to the RS232 standard (±12V) using a chip such as the popular MAX232. Fig.9 shows a typical circuit to achieve this.

To enable serial communications you use the open command as follows:

```
OPEN "COM1:9600" AS #1
```

This will enable the COM1 serial interface and take control of the external I/O pins 15 (Rx) and 16 (Tx). The baud rate is set to 9600 bits per second and you can use the file identifier (#1) in exactly the same manner as if you were reading or writing data from a disk file.

For example, you can use commands such as PRINT #1, "data" to send data and INPUT$(1, #1) to receive a character. When you have finished, you can close the serial interface with the command CLOSE #1, which will return control of the I/O pins to the SETPIN and PIN commands.

One useful feature of the serial interface is that you can issue the command:

```
OPEN "COM1:2400" AS CONSOLE
```

This will open the COM port, set the baud rate to 2400 and attach it to the input and output data streams from MMBasic. Anything received from the COM port will be sent to the MMBasic interpreter as if it had been typed on the keyboard. Similarly, any output to the video screen (except graphics commands) will be sent out on the COM port's transmit line.

This means that you can enter data and control the Maximite via an external serial link. This link could be connected to a modem or even to a serial/Ethernet module for remote control of the computer or the program running on it.

When a COM port is opened as a console it will remain in this mode, regardless of commands such as NEW and RUN which normally close all files and COM ports. The only way to terminate this mode is with a CLOSE CONSOLE command.

Typically, the command to open a port as a console would be included in the "A:AUTORUN.BAS" file so that the console

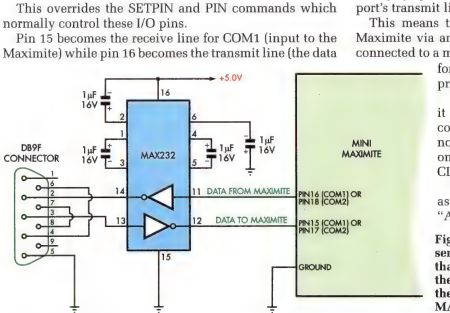


Fig.9: if you want to connect the Maximite's serial interface to a modem or other device that uses RS232, you will need to convert the voltage levels to ±12V as required by the standard. This circuit uses the popular MAX232 chip to do just that.

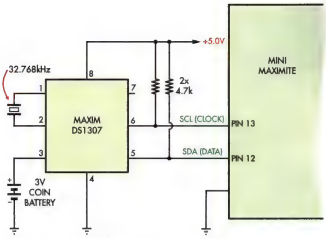


Fig 10. Many chips use the I²C protocol – this diagram shows how to connect such a component to the Maximite, in this case the Maxim DS1307 real time clock chip.

is immediately setup on power up.

I²C interface

The Inter Integrated Circuit (I²C) bus was developed by the electronics giant Philips for the transfer of data between integrated circuits. The protocol has been adopted by many manufacturers and you can now buy devices including memory chips, timekeeping chips, speech synthesisers and more – all using the I²C interface.

When enabled the I²C interface will take control of pins 12 and 13 on the Maximite's external I/O connector. As with the serial interface this will override the SETPIN and PIN commands which normally control these I/O pins. When the I²C interface is closed control is returned to these commands.

Pin 12 becomes the I²C data line (SDA) and pin 13 the clock (SCL). Both of these pins should have external pullup resistors installed (a typical value is 4.7kΩ connected to +5V). Fig.10 illustrates this arrangement using the popular Maxim DS1307 real time clock.

Both master and slave I²C modes are fully implemented and you can have both operating simultaneously with bus speeds set anywhere in the range of 10kHz to 400kHz. Other features include optional 10-bit addressing, address masking and general call, as well as bus arbitration (ie, bus collisions in a multi master environment).

The commands for controlling the I²C interface are documented in the updated Maximite User Manual so we will not go into the details here but suffice to say that all the features of the protocol are supported.

SPI interface

The Serial Peripheral Interface (SPI) communications protocol is another popular protocol used to send and receive data between integrated circuits.

In the Maximite this implementation is suitable for moving small amounts of data to and from a chip like an accelerometer but not for shifting large amounts of data from EEPROMS, etc. The SPI function in MMBasic acts as the master (ie, the Maximite generates the clock).

The standard SPI signals (MISO, MOSI and CLK) can be any external I/O pin on the Maximite and the command can transfer data with up to a 500kHz clock. The SPI interface can also communicate with any number of SPI devices connected to the Maximite at the same time.

Other firmware improvements

Many other features have been added to the firmware to make your life as a programmer easier. For a start it now contains an editor (the EDIT command) that can be used to modify a program line in memory without having to retype the whole line. The RENUMBER command will renumber a program for you ensuring that the line numbers are neat and consistent. This command will also change any references to line numbers (for example, in a GOTO command) so that they match the new numbering scheme.

The SAVEBMP command will save an image of the video screen onto the SD card or internal flash drive while the PIXEL command/function can be used to change or examine the video memory directly.

Finally PEEK and POKE commands have been implemented for readers who want to get into the internal workings of the PIC32 chip and the interpreter.

So there you have it, a full-featured and low-cost computer in a miniature package that you can plug into your own creation. It is easy to use and you can easily write programs for it.

So, what will your next creation be? SC

PCBs and Programmed PICs

For those wishing to build their own projects and source their own components, SILICON CHIP is now able to offer both the PCB and the pre-programmed PIC chip (this chip suits both the MiniMaximite and Maximite projects and comes with the latest software from Geoff Graham).

For more information, contact SILICON CHIP direct: see phone no. and email address on p102.

NEXT MONTH:

We'll have a look at some interesting Maximite/mini-Maximite applications and ideas submitted by readers!

Maximite resources

The author's web site for updates and other downloads:	http://geoffg.net/maximite.html
An active forum discussing the Maximite and other micros (a good place to start if you need help):	www.thebackshed.com/forum/forum_topics.asp?FID=16
The Altronics kit for the full sized Maximite:	www.altronics.com.au/index.asp?area=item&id=K9550
Alternative, assembled versions of the Maximite:	www.dontronics-shop.com/the-maximite-computer.html
A large range of expansion boards for the Maximite:	www.hamfield.com.au
An example of running MMBasic on a Microchip development board:	www.elproducts.net/chips16.html
A reader who could not wait for the kit to become available:	www.carnut.info/maximite

SERVICEMAN'S LOG

Hiring a new technician is never easy

Dave Thompson*

As any business owner will tell you, one of the hardest parts of the job is hiring the right people. In our industry, we not only need people with technical skills but they must be able to deal with customers as well.

Items Covered This Month

- Hiring new staff isn't easy
- Mainframe madness
- Jeil JPA-1200 PA amplifier

**Dave Thompson, runs PC Anytime in Christchurch, NZ.*

In my opinion, service people have a more difficult task when it comes to hiring people than most other employers. If all you need is a bubbly receptionist to meet and greet and cheerily answer the phone, then there are gazillions of suitable candidates. However, if you need someone with the technical abilities of a Mission Impossible team, the sales acumen of an East-End market stall holder, the phone manner of a drive-time radio announcer and the charm of a Latin film star, the pickings are mighty thin.

One of the big problems with advertising for a computer technician is the fact that every male in the country with their own computer/Xbox/PlayStation fancies himself as an expert, as long as he could just get a start in the industry. This sees me dealing with recruiting problems that, for example, hospitals advertising for new brain surgeons wouldn't have.

No one imagines quitting his or her long-term job as a forklift driver (or whatever) and becoming a brain surgeon overnight but that sort of leap seems perfectly acceptable when I advertise for a computer technician. And while many people may know how to break a computer down and rebuild it, that doesn't make them a technician; someone who can diagnose and fix tricky hardware and software problems. The number of "I currently drive a forklift but have always wanted to be a computer tech" job applications I get each time I advertise for new staff is staggering. It would be funny if it wasn't so time-consuming and soul destroying.

By now you've no doubt guessed that that little rant is leading up to something. Well, just recently my sole remaining staff member, who had been with us for three years through the double-whammy of recession and earthquakes, decided he'd had enough. The stress and strain of the quakes, as well as being without his partner who'd left the area a year earlier, had finally become too much. Losing such a good technician was a real blow and although I knew that the day would inevitably come, it doesn't make things any easier when it finally does. If a business has six staff, losing someone is not the end of the world. But when your only staff member leaves, it means maximum upheaval.

Not only do you have to cope with the extra workload alone but you also have to go through the aforementioned recruiting process. And when you do finally hire someone, it's usually followed by weeks (if not months) of hand-holding and in-house systems training, while still coping with your own job and rectifying the inevitable mistakes made by the new employee during those first few weeks.

It starts with the CVs and this time, I had 62 to contend with. For various reasons, about half were obvious rejects from the outset, leaving about 30 to vet.

Once I had decided which applications sounded feasible, I sent out an email containing further details of the job description and the wages offered. About half never replied (suits me!) while the rest either declined the offer or wanted to take it further. The "nays" then got a polite "thank you for applying" letter while the "ayes" were invited to come in for an interview.

Most (but not all) of those who came in were goners the moment they walked through the door. It may come as a surprise to some people but averted eye-contact handshakes, sloppy dressing, old gym-shoes, and not washing or shaving for a week are real turn-offs. A body odour of roll-your-owns, fush and chups (that's how we Kiwis say it) and cheap booze are certainly not the attributes I look for in a potential employee!

It was my good fortune that one applicant in particular stood out from the rest (who were also very good) and he is now on the payroll and impressing me on a daily basis. Not only am I teaching him the ways of our business and a few tricks of the trade along the way but he is also teaching me some valuable new skills. It's a win-win situation for both of us.

While in the past I have usually had to do the best with what was available, this time I was spoilt for choice. It seems that the quakes and the earlier recession here in NZ has forced many companies to shed staff and hunker down, so the job market is now flush with well-qualified and eager-to-work candidates.

I feel terrible about not being able to hire every one of the decent prospects but that's the reality of the workplace. I can at least give one guy a good paying job and in return he helps keep our business afloat. I'd call that a pretty fair deal.

Mainframe madness

K. C. of Mount Dandenong has an interesting story on the chaos caused by a "faulty" mainframe computer that was used in the control room for a large slab of the UK electricity grid. Here's what happened . . .

Back in 1985, I was a telecommu-

nications engineer in the UK working for the CEGB (Central Electricity Generating Board). The CEGB was a nationalised industry which owned and operated the power system in England, Scotland and Wales. This consisted of over 100 power stations and around 200 switching substations, interconnected by some 7000km of super-grid power lines which mainly ran at 400,000V and 275,000V.

This system was centrally managed from the National Control Centre (NCC) in London. Each of the super-grid substations and power stations sent in real time telemetry via landline to the NCC, consisting of indications of circuit breaker positions, power flows, voltage and frequency. Given that each substation might have 20-30 telemetered items, the sum total of items ran into the thousands – all of this information arriving in real time.

In order to process and display this information we used twin Ferranti Argus 500 mainframe computers, configured as a main and standby pair. These computers received the raw incoming data streams and processed the information into meaningful data which was then displayed on 52cm Ferranti CRT terminals. These terminals were very simple units, with no inbuilt processing capability or memory whatsoever – just an X and a Y amplifier to drive the tube deflection plates.

Despite this limitation, the units produced sophisticated "cursive" displays, showing schematic overviews of the super-grid with real-time data overlays which could be zoomed in and out and scrolled from north to south and east to west. More detailed individual schematics of every substation could also be called up when needed. All of the processing power to achieve this was provided remotely by the on-line Argus 500 mainframe.

Each of the CRT display units had an associated special Ferranti keyboard unit for input data. These had 28 keys with backlights, all the keys being hardwired in parallel back to the mainframe. Because of the parallel connectivity, two 25-pair multi-core cables were required to connect each keyboard back to the mainframes – one multi-core cable to the on-line machine and a second multi-core to the standby. Like the CRT displays, the keyboards had no intelligence or memory capability; they were just simple switches and all the keyboard processing was carried out by the on-line mainframe.

ONE OF THE HARDEST PARTS OF THE JOB IS HIRING THE RIGHT PEOPLE...

The on-line mainframe drove a total of 20 Ferranti CRT/keyboard units – 12 in the main National Control Room and a further eight distributed throughout various offices. In addition, the mainframe also drove the "Wall Diagram"; a large "mimic" display of the super-grid about 4.5 metres high by 15 metres long that took up most of one complete wall of the control room.

Now you might imagine that handling all this real-time data and processing it in real time to drive all these systems would require a processor with a fairly impressive specification. And you would be right – except that the specifications were impressively low! Each of the Argus 500 mainframes had a CPU which ran at a clock speed of 1MHz, while the memory capacity was limited to 96 kilobytes of ferrite-bead core store.

We also had the luxury of two hard disc drives on each mainframe for data storage. The discs in these were one metre in diameter, rotated at 3000 RPM, were belt driven by a 2kW motor and stored a luxurious six megabytes (6000 kilobytes) of data!

It's interesting to compare this specification with the processing power of a modern desktop PC. Assuming a PC running at 3GHz, with 2GB of RAM and a 1Tb hard drive, this would have 3000 times the processing speed of the Argus mainframe, 20,000 times the memory capacity and 160,000 times the hard drive capacity!

These are truly staggering comparisons and not only highlight the vast amount of raw power packed into a modern desktop but also the humble nature of the Argus 500 specification. And yet a modern PC would be totally overwhelmed by the processing workload of the Argus 500s

Why is that so? The answer lies in the machine operating systems. Modern desktops run operating systems which essentially exist to make the programmers' life easier. Software is written using development environments and programming languages which are extremely wasteful and inefficient of processing power and memory space. Each new generation of software usually builds on the previous generation, adding more functionality to the end product but further compounding demands for processing power, memory and disc space.

The end result is that most users nowadays are genuinely unaware of the full power of the raw hardware hidden within their desktop or notebook.

By contrast, the Argus 500 mainframes did not have an operating system – all of the functions normally carried out by the OS were hard-coded into the application software. The application software itself was not compiled or interpreted in any language – it was handwritten in pure machine code and it ran like greased lightning!

~THE CONTRACTORS HAD CARRIED OUT THEIR INSTRUCTIONS WELL

This did have some major constraints though. Static system data was enshrined in the machine code and even simple changes to this essentially needed an application rewrite. To this end, we employed a full-time section of three software engineers. My own post as a telecommunications engineer was in the hardware section, which was responsible for maintaining all the telemetry links as well as the Argus 500 mainframe hardware.

We had many challenging faults to cope with over the years but the most memorable of these occurred one sunny afternoon in 1985. Things had been fairly quiet of late but this peaceful interlude was ended when my phone rang. It was the Senior Control Engineer and he informed me that many of the displays in the control room had "gone crazy" and that all the remaining displays were frozen. The "crazy displays" were flipping randomly between different display pages about once a second and none of the display units would respond to any of the keyboards.

In addition, the Wall Diagram had frozen up and would not show any system changes. As a result, the control engineers were essentially "flying blind", with no up-to-date information on the state of the super-grid. Under such conditions, there was a very real risk of minor faults on the super-grid escalating unchecked into major geographical power outages.

These symptoms had all the appearance of an unusual software fault and the standard operational procedure for this was to restart the on-line mainframe. This took a couple of minutes to complete but the end result was no improvement – all the displays were still either flipping randomly or frozen.

This indicated that the fault was probably a hardware failure rather than a software problem and the next step was therefore to initiate a changeover to the standby mainframe. Such a changeover was fully automatic – you only had to press the big button marked "STOP" on the on-line mainframe and the hardware watchdogs kicked in after 10 seconds and started the process of bringing the standby machine on-line. This was an impressive process, as the standby machine would run through a full suite of "health checks" on all its peripherals before taking over, accompanied by a very pyrotechnic display of flashing console lights and intermittently ringing bells.

You can imagine the dismay which ensued when the standby machine finally went into on-line mode – and displayed exactly the same fault!

By now, the control room facilities had been "off the air" for 10 minutes and the pressure was on to sort things out quickly. Unfortunately though, we were out of quick options. The next "escalation stages" were time-consuming, involving reloading the application software from tape back-up (about 15 minutes) and, if that failed, running hardware diagnostic programs (which could take hours). Normally, these operations were carried out at leisure on the standby machine following a successful on-line changeover but in this case neither of the mainframes would play ball.

After an elapsed time of some 30 minutes, we had reloaded the software onto the original on-line machine from the tape archive and restarted it but all to no avail. By now, the phone calls from the control room enquiring about our progress were becoming increasingly desperate.

It was time to start running hardware diagnostics but we were faced with the problem that two independent suites of hardware had failed in the same way, with the same symptoms. So what to test? The only hardware items common to both suites were the Ferranti keyboard units and the CRT displays. The CRT displays were "too simple" to be responsible for such a fault, while the keyboards were internally duplicated with independent contacts on each key going separately to each mainframe.

In any event, keyboard faults always caused very straightforward symptoms and we couldn't imagine any way in which a keyboard fault could create such havoc.

At this point, another hardware colleague who had not so far been involved, turned up and we started giving him a quick rundown on the events so far. Part way through this, he stopped me in mid-sentence and it was obvious from his expression that some dire thought had crossed his mind. And that dire thought involved some contractors who were working for him in the teleprinter room.

This room housed about a dozen Creed 444 teletypes which were used for operational communications. These were being replaced by programmable fax machines and my colleague had given them instructions to remove all the teletypes, along with their desk units and all the teletype cabling.

We quickly dashed across to the teleprinter room and it turned out that the contractors had carried out their instructions well – too well, in fact. The room was bare and all the teleprinter cabling had been removed. This cabling had originally gone through floor ducts to some cable trunking which ran from floor to ceiling. Not only had the contractors removed the teleprinter cabling, they had also put a hacksaw through all the other cables in the trunking, at both floor level and ceiling level, and thrown the amputated cable sections in a skip!

Unfortunately, many of these cables were 25-pair multi-cores which ran from some of the control room keyboards to the mainframes in the apparatus room. And due to the fairly brutal way in which these had been hacksawed through, numerous short circuits had been created on the cable stubs leading to the mainframes, which had interpreted the multiple shorts as continuous multiple key presses. These "key presses" had created the "crazy displays" and had also overloaded the mainframes to such a extent that they could not respond to any of the unaffected keyboards.

We spent the next 10 minutes with sidecutters, hastily chopping back insulation on the multi-core cable stubs and separating out the individual wires to remove all the shorts. A few minutes after that, we had a mainframe back on-line and running successfully, albeit with some of the control room keyboards out of action. I worked over the next couple of days running new multi-core cables for these, all the time roundly cursing the limited intelligence of the contractors responsible for my labours.

Needless to say, after that experience, we introduced some new rules concerning effective supervision of contractors!

You gets what you pays for!

SILICON CHIP staff member Ross Tester recently bought a "pig-in-a-poke" on eBay. Well, actually, it was a PA amplifier that didn't work. Here's his story . . .

You know that old adage "if it sounds too good to be true, it probably is." Or perhaps the quote attributed to PT Barnum is even more applicable: "there's one born every minute".

I had been looking out for (yet another!) PA amplifier for a while. The problem was, it had to be as cheap as possible because the surf club which needed it was, not to put too fine a point on it, broke. They needed the PA amplifier to go with the distributed speaker system I'd put in for them a while back. The fact that they took several months to pay for the speakers was a fair indication that they didn't have a bean to bless themselves with.

It's these love jobs which we take on that sometimes come back to bite us!

Anyway, I needed to reclaim my "loaner" amplifier before someone else assumed it belonged to the club. I don't use it all that often but when ever I did need it, there always seemed to be a function booked where they simply "had" to have it available. The only answer was replace it.

I didn't need too much in the way of features and it only had to drive a dozen or so 5W speakers. In the end, I figured that something capable of about 100W or so would be suitable, 100V line of course and with three or four input channels – one to suit

a wireless microphone and another couple to allow an MP3 or CD player to be plugged in.

I'd bid for several suitable amplifiers on eBay over the months but either missed out because they went too high or because I clean forgot about bidding as the auction closed.

Then one popped up which looked pretty good – an AWA Jeil JPA-1200 PA amplifier with a starting price of only a couple of dollars.

The brand name was a bit of a mystery so I did a net search to find out what I could. Perhaps I should have heard the alarm bells clanging when the search revealed practically no information. Unfortunately, I couldn't find anything remotely resembling a circuit diagram, specifications or even a reasonable description.

But I bid for it anyway. I reasoned that if I got it for a really good price I wouldn't be too much out of pocket if it was unsuitable. Little did I know . . .

A few days later it was mine for the princely sum of $10.50 (someone else bid $10 but my $15.60 autobid won it for me). It had to be picked up and the address was quite a distance away, in the southern suburbs of Sydney. But as luck would have it, I was going away on holidays the very next day and would be driving almost past the seller.

Alarm bell two should have been clanging when he informed me (by text message) that it had to be an immediate pick-up because he was going overseas!

When I returned from my few days away, amplifier under the arm, I figured I probably should check it out before installing it at the club – just in case. It was obviously used but overall not too knocked around so I was quite confident.

It powered up appropriately and the LED VU meter did all the right things but much to my disgust, there was virtually no output. There was some but when I tried to measure it, it was right down in the fraction-of-a-watt area, not the 100W+ that I was expecting. The sinewave I fed into the input appeared, well, decidedly non-sine at the output!

The amplifier was suddenly taking on the appearance of a canine: I'd been sold a pup!

Next step was, of course, to check the fuses. They were all OK and then I figured I needed to lift the lid, which fortunately was quite easy. Perhaps too easy? The case screws were not at all tight so someone had been there before me.

Inside, there was some dust but no more than expected considering its age. There were a few wires simply going nowhere but on closer analysis, I concluded that these were probably for the optional tuner or cassette/CD player which was obviously catered for on the front panel.

A closer inspection then revealed just why it wasn't working "quite" correctly: one of the output transistors was missing completely and some of the others appeared to have been unsoldered, at least to some degree.

Obviously someone had "had a go" at repairing the amplifier and then when they had no luck, decided to cut their losses and flog it off to some mug – me – on eBay.

eBay does, of course, have a disputes resolution procedure. But was it worth it for a $10 purchase? And of course, the seller could have easily claimed it was working fine when he sold it. I decided it wasn't worth the hassle.

So what to do? Cut my losses and consign it to the bin, as some of my work colleagues laughingly suggested? Or try to repair it, just in case it was easier than the last bloke had found?

Anxious to remove the egg that was now spread over my face I chose the latter.

The output transistors were four 2SC4503s which, while not common, are available via the web. But the price! They were around $15 each plus freight, which would make my $10 amplifier look nothing like a bargain. And even then, the amplifier might still turn out to be bin material.

Replacing the output transistors could solve the problem but there was no guarantee it would work. And with no circuit diagram, I wasn't willing to invest a lot of time tracing it out.

I downloaded the specifications for the 2SC4503 transistors and found they were not particularly unusual – 100V, 30A 80W NPN. Would some "garden variety" rough equivalents do? Fortunately, I had some 2SC3281s on hand. I'd purchased a dozen or so of them some time back for just over a dollar each and had left them in the parts bin, just in case. The best part was that they were pin-for-pin equivalents, even if they weren't insulated tab as the originals were. And while the 2SC3218s are not as highly-rated as the originals, a quick back-of-the-envelope calculation suggested they should easily handle the task.

As a result, I decided that I would just replace the output transistors; if the amplifier didn't work after that I would cut my losses and have a new boat anchor.

It didn't take too long to remove the bottom of the amplifier case, gaining access to the copper side of the PCB. Removing the old transistors and replacing them with the new ones took only a few minutes. The most fiddly part was aligning the transistors and the now required insulating washers with the tapped heatsink.

At this stage, I didn't bother replacing the lid – what's the point when all you want to do is see if it passes the smoke test? Fortunately, it did – and nothing seemed to be getting at all hot under the collar. So I connected a load, a scope and an oscillator – and powered it up again.

Oh bliss, oh joy! A nice clean scope waveform. And when I wound the wick up, it stayed that way. Plenty of power – and still nothing untoward happened component-wise. The scope told me that I had about 80V p-p into the load, or more than 100W available.

Finally, I was able to replace the case and soak-test it for a day or so. With all appearing well, I took it to the club and connected it to the various inputs (radio mic, fixed mic, background music source, etc) and the speakers. It worked fine – and is still working fine!

There is a moral here, of course. Buying anything on eBay has a risk. It's worse buying from overseas, of course, but this incident proved that you can even be caught buying local.

This particular case has a happy ending because I was in a position, even without a circuit diagram, to make an effective repair. But the vast majority of people would not be. It would be a total loss.

Finally, if any Silicon Chip reader happens to have a manual (or even a circuit) for a JEIL JPA-1200 mixer amplifier, I'd be delighted to hear from you. SC

Covert Surveillance

PIR DRIVEN SECURITY CAMERA

This unit will take still photographs in JPEG format when triggered by a moving object. 16MB internal memory is included which stores up to 200 images or expand the memory by a 2GB SD card (not included). Images can be downloaded via USB connection.

- Focal range is between 2.5 & 4.0m
- 640 x 480 resolution; USB cable included
- Requires 4 x AA batteries
- Dimensions: 130(H) x 95(W) x 35(D)mm

QC-8013

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Video can be recorded at 720p and the LEDs enable night time and low-light recording. It takes photos, and requires a MicroSD (up to 32GB) card. Handy tool for security guards or even for home surveillance applications.

- AVI format
- Colour
- Recording time: up to 4 hrs
- Video compression: MJPEG
- Dimensions: 111(L) x 32(D)mm

QC-8010 WAS $129.00

$99.00 SAVE $30.00

3MP MINI HD DIGITAL VIDEO CAMERA

This ultra portable HD colour video camera and recorder has endless uses for sports, business and surveillance. The 2GB internal memory will hold up to 50 minutes of video (20min HD) or over 3000 photos. Recharges via USB for about 4 hours of use. Pocket clip and desk stand included.

- Image resolution: 3MP
- Video resolution: 1280 x 720p
- Dimensions: 23(H) x 78(H) x 14(D)mm

QC-8005 WAS $119.00

$79.00 SAVE $40.00

3.5" LCD CAMERA KIT

The kit incorporates a 3.5" LCD screen and CMOS colour camera. The 3.5" TFT LCD gives real-time video monitoring and the microphone in the camera provides audio either through the speaker in the display unit or via headphone outlet. The LCD unit can take two AV inputs, so you can add a second camera if required. 20m power/video cable and mains plugpack included.

- IR illumination
- Spare camera available separately **QC-8009** $69.00
- Dimensions: 130(W) x 80(H) x 22(D)mm

QC-8007 WAS $149.00

$129.00 SAVE $20.00

MINI DVR KIT WITH BUTTON-HOLE CAMERA

Capture meetings, conferences or lectures with this high definition video and audio mini DVR kit. Stores up to 32GB on an SD card allows you to view the video on the 2" TFT LCD colour screen with different buttonhole options so it's completely covert and discreet. Includes a LiHon rechargeable battery, charger, AV leads, USB cable and dummy buttons for disguising the camera.

- Approx 10 hours of video on 32GB SD card (not included)
- 420TV lines camera resolution
- Dimensions DVR: 65(W) x 54(H) x 14(D)mm
  Camera: 22(W) x 34(H) x 15(D)mm

QC-8006 WAS $249.00

$199.00 SAVE $50.00

COLOUR SPORTS CAMERAS

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Make your own sports action videos while mountain biking, skateboarding, BMX, skydiving, bungee jumping etc. It straps onto your helmet and has a super-sticky adhesive mount to keep it in place. Simple one-button operation to start recording and uses SD cards (not included) up to 32GB for storage. Requires 2 x AAA batteries.

NOTE Helmet not included

- Image resolution: 1.3MP
- Video resolution: 640 x 480 @ 30 fps
- Dimensions: 90(L) x 50(Dia.)mm

QC-3238 WAS $49.00

$39.00 SAVE $10.00

Waterproof Sport Action Camera

Mount to the bicycle or motorcycle handle bars for an action packed video recording of every jump straight onto a MicroSD card (not included) with up to 32GB of storage. 360° rotating base, designed for wet weather conditions and includes an optional helmet strap plus USB & TV out cables.

- Image resolution: 1.3MP
- Video resolution: 720 x 480 @ 30 fps
- Built-in rechargeable lithium battery
- Dimensions: 87(L) x 26(Dia.)mm

QC-8012 WAS $79.95

$69.95 SAVE $10.00

Mini Waterproof HD Video Recorder

Strap it onto your vehicle, head, goggles or helmet and start recording directly in 720p high definition video. Records directly to a MicroSD card (not included) with up to 32GB of storage and up to 2 hours of recording time. Great for capturing footage of motorsports, water sports, cycling, skateboarding or hunting adventures. Recharges via a USB cable (included).

- Image resolution: 3MP
- Video resolution: 1280 x 720 @ 30 fps
- Water resistance: 10m
- Dimensions: 78(L) x 22(Dia)mm

QC-3256 WAS $199.00

$149.00 SAVE $50.00

ROBOT CHASSIS KITS - BUILD THEM!

Robot Chassis/Platform - Light Duty

This kit uses a piece of rigid fibreglass circuit board as the vehicle chassis. It has a generous area at the front for circuit prototyping, subassembly mounting, etc. It includes 2 x drive motors, gear sets and fastener hardware. Kits like this solve the hard-to obtain parts for robotics projects.

- Hand tools, including a small soldering iron will be needed for assembly
- Suitable for ages 12+
- Chassis dimensions: 140(L) x 85(W)mm

KR-3132 WAS $34.95

$24.95 SAVE $10.00

Robot Chassis/Platform - Heavy Duty

The vehicle chassis for this unit is an extremely rigid, glass reinforced ABS plastic case. Comes assembled with 2 x 6V motors with gear trains. Each motor is securely fitted to a 48mm dia. driving cog. There are slots in the chassis for PCBs but no electronics is included (6 x AA battery holder is included). Accessories included - gear grease, Allen key.

- High quality, high integrity product
- Suitable for ages 12+
- Chassis dimension: 172(L) x 130(W) x 60(H)mm

KR-3130 WAS $69.95

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Arrival dates of new products in this flyer were confirmed at the time of print. Occasionally these dates change unexpectedly. Please ring your local store to check stock details. **Prices valid from 24th October to 23rd November 2011.** All savings are based on original RRP

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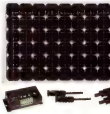
Premium Packages

The included premium Pulse Width Modulator (PWM) charge controller is feature packed to ensure your battery is efficiently charge and maintained.



120W Premium Package
1 x 120W monocrystalline solar panel (ZM-9098)
1 x 12V 20A PWM charge controller (MP-3129)
1 x female PV connector (PS-5100)
1 x male PV connector (PP-5102)

ZM-9304 WAS $680.00
NOW $600.00 SAVE $80.00

FROM $600.00

160W Premium Package
ZM-9303 WAS $990.00
NOW $780.00 SAVE $110.00
240W Premium Package
ZM-9306 WAS $1260.00
NOW $1100.00 SAVE $160.00

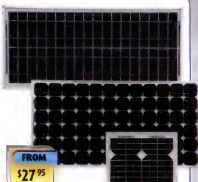
Save up to 12% off

POWERTECH MONOCRYSTALLINE SOLAR PANELS

A range of efficient solar panels with reliable performance and robust construction using tempered glass and aluminium frame. Sizes range from 5W to 175W. Junction box with cable glands are fitted to the larger panels (65W and above) and the smaller panels are fitted with a slimline junction box with silicon cable sealant. All junction boxes have short UV stabilised output cables and bypass diodes included. See website for more info.

- 25 year limited warranty

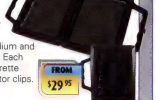
		Was	Now	Save
12V 5W	ZM-9091	$32.95	$27.95	$5.00
12V 10W	ZM-9093	$59.95	$49.95	$10.00
12V 20W	ZM-9094	$115.00	$99.00	$16.00
12V 40W	ZM-9095	$219.00	$185.00	$34.00
12V 65W	ZM-9096	$349.00	$299.00	$50.00
12V 80W	ZM-9097	$399.00	$339.00	$60.00
12V 120W	ZM-9098	$579.00	$499.00	$80.00
24V 175W	ZM-9099	$849.00	$729.00	$120.00



FROM $27.95

12V BRIEFCASE SOLAR CHARGERS

Convenient briefcase sized solar chargers for keeping a car battery topped up while on holidays or in storage. Three sizes for small, medium and large cars or 4WDs. Each terminates in a cigarette lighter plug or alligator clips.



FROM $29.95

2W Charger

- Dimensions: Closed: 185(L) x 154(W) x 34(H)mm
  Open: 304(L) x 185(W) x 17(H)mm

ZM-9036 WAS $39.95 NOW $29.95 SAVE $10.00

4W Charger

Dimensions: Closed: 237(L) x 229(W) x 34(H)mm
Open: 445(L) x 237(W) x 17(H)mm
ZM-9037 WAS $49.95 NOW $39.95 SAVE $10.00

7W Charger

Dimensions: Closed: 335(L) x 250(W) x 36(H)mm
Open: 492(L) x 335(W) x 18(H)mm
ZM-9038 WAS $79.95 NOW $59.95 SAVE $20.00

12V SOLAR BATTERY CHARGERS

Ideal for charging sealed lead-acid batteries. These chargers can be mounted on a flat surface or on their brackets. Supplied with mounting brackets, blocking diode, 2m output lead cable with alligator clips. Maximum voltage 18V for both units.

12V 1.26W

- Panel size: 159(H) x 175(W) x 17(D)mm

ZM-9016 $44.95

FROM $44.95

12V 4.5W

- Panel size: 187(H) x 255(W) x 17(D)mm

ZM-9018 $99.95

CARAVAN/MARINE POWER SYSTEM KIT - 12V 1500W, 320W SOLAR, 300AH BATTERY

An ideal mid-level power system for caravans and boats, or even a smaller motorhome. Includes everything to make a complete 12V house battery system with enough stored battery power for medium stints of free camping without AC power. Includes a Rich Electric SuperCombi 1500W-12V interactive inverter-charge, 4 x 80W mono crystalline solar panels, 2 x 150Ah AGM batteries, programmable dual battery system and most of the accessories required to round out the system. See our website for full details and performance.

MP-9013 WAS $6645.00

$6225 SAVE $220

Also available: **Caravan / Motorhome / Marine Power System Kit - 24V 525W Solar MP-9015**
WAS $9979.00 NOW $9479.00 SAVE $500.00

SOLAR POWERED WATER PUMPS

Let the sun run your water feature! Comes with a solar panel, cable and ready to use pump assembly. Built in electronic smarts to regulate power delivery during cloudy periods.

0.9W Solar Water Pump

- 140 l/hr 7V
- Power consumption: 0.9W
- Cable length: 2m

ZM-9200
$49.95

FROM $49.95

2.4W Solar Water Pump

- 200 l/hr 12V
- Power consumption: 2.4W
- Cable length: 2m

ZM-9202 $99.95

AMORPHOUS SOLAR PANELS

These amorphous silicon panels have a strong aluminium frame and the cells are protected by a strong, clear glass window. They are long lasting and will maintain 80% of their performance rating, even after 20 years of use.

- 20 years limited warranty

6V 1W	ZM-9020 $19.95
12V 2W	ZM-9024 $29.95
12V 4W	ZM-9026 $49.95
12V 10W	ZM-9030 $89.95
12V 15W	ZM-9045 $129.00
12V 40W	ZM-9034 $299.00

Now New & improved. Includes protective plastic corners & battery clips

FROM $19.95

Limited stock on sale items.
All Savings are based on Original RRP

Jaycar Electronics
Better, More Technical

MINI DISPLAYPORT CONVERTERS

Mini DisplayPort to DisplayPort/HDMI/DVI Converter

NEW 2011

Converts to high definition displays that take HDMI, DVI or DisplayPort. Fully powered from the mini DisplayPort of your input device.

- Supports DisplayPort 1.1a
- DisplayPort 1.1a Dual-mode output with max resolution of 2560 x 1600
- Dimensions: 88(L) x 44(W) x 15(H)mm

WQ-7427

$39.95

Mini DisplayPort and USB Audio to HDMI Converter

NEW 2011

Connects video and audio up to a large flat screen TV from a DisplayPort equipped device. It converts DisplayPort and analogue audio through a USB port to a HDMI port.

- Converts video and audio to HDMI
- Mini DisplayPort 1.1a and USB 2.0
- Powered from mini DisplayPort and USB port
- Resolutions: 480p, 720p, 1080i, 1080p
- Dimensions: 79(L) x 55(W) x 11(H)mm

WQ-7426

$79.95

POWERED CAT5 VGA BALUNS WITH AUDIO

Transmit VGA and audio signals across a standard UTP or STP Cat-5 cable for distances up to 300 metres. Use for home or commercial applications where a standard VGA cable can't reach or to run VGA signals through existing wiring in a wall or ceiling. Ideal for VGA monitors or projectors. Supports up to 1920 x 1200 resolution. Supplied as a transmitter and receiver pair with plugpacks.

- Vertical frequency range: 60/75/85Hz
- Supported resolutions: 640x480 to 1920x1200
- Dimensions: 441(L) x 202(W) x 45(H)mm

AC-1671

$119.00

NEW 2011

AUDIO/VIDEO CABLE FOR iPOD®/iTOUCH®/iPHONE®

NEW 2011

Connect your Apple® device to a large screen TV, projector, or home theatre audio setup. Uses RCA connectors for video and audio connection, and a USB plug for charging or connecting to a computer.

- Cable length: 1.5m
- Compatible with: iPod® photo, iPod® 5th Gen, iPod® Nano 3rd & 6th Gen, iPod® classic, iPod® touch (1st & 4th Gen), iPhone®, iPhone 3GS®, iPhone 4®, iPad®, iPad2®

WC-7698

$39.95

HDMI TO COMPOSITE AV CONVERTER

NEW 2011

This HDMI to composite AV converter will give a standard Y/R/W RCA connection from any HDMI signal. Ideal for feeding a set top box or media device into an existing AV distribution system for clubs or business. Also useful for situations where you have existing AV cables and no need to upgrade to a full HDMI signal path.

- 5V 2A power supply included
- HDMI input format: 480p / 576p / 720p / 1080i / 1080p
- PAL / NTSC selectable
- Input: HDMI Type A female
- Output : RCA Yellow/Red/White
- Dimensions: 102(L) x 100(W) x 25(H)mm

AC-1623

$99.00

TIE CLASP MICROPHONES

Economy Tie Clasp Microphone

Electret condenser tie clasp microphone. Supplied with alligator clip to attach to tie or shirt and 2 metres of cable to 3.5mm plug. Ideal for lectures, stage, video recorders etc.

- Dimensions: 30(L) x 13(Dia.)mm (excluding grommet)

AM-4092

$19.95

High Sensitivity Tie Clasp Microphone

Ideal add-on microphone for your digital voice recorder or other portable recording device that only has a tiny built-in microphone. Light and unobtrusive, so is ideal for recording interviews, conferences or webcasts.

- Type: Condensor, tieclasp
- Termination: 3.5mm plug
- Excellent sensitivity and low noise
- Polar pattern: Omnidirectional
- Cable length 1.2m

AM-4101

$24.95

Stereo Tie Clasp Microphone

A handy accessory for stereo digital voice recorders or recording in stereo on your laptop. Independent left and right microphones for true stereo. Suitable for recording conferences, music etc.

NEW 2011

- Type: Unidirectional stereo
- Termination: 1m lead, 3.5mm stereo plug

AM-4106

$24.95

VGA/AUDIO SPLITTERS

Splits a computer's VGA and audio signal to two or four identical streams. The splitter provides fast, flexible solutions for test bench facilities, data centres or video broadcasting such as remote monitoring, presentations, education and stock quotes etc. Supports VGA, SVGA, XVGA and Multi-Sync. Mains power adaptor included.

NEW 2011

- Bandwidth up to 500MHz
- Resolution up to 1920 x 1200 and 1080p
- Transmit video/audio up to 15m

2 Port

- Dimensions: 125(W) x 25(H) x 72(D)mm

YN-8075 $69.95

FROM $69.95

4 Port

- Dimensions: 165(W) x 46(H) x 98(D)mm

YN-8076 $99.95

ACTIVE COMPONENT VIDEO TO HDMI CONVERTER

This converter is perfect for when you have run out of component video inputs, but have plenty of HDMI inputs spare on your TV. This converter will take the component video (YPbPr) and digital audio output from your DVD player, set-top box or Digital Pay TV box - and convert them to a HDMI signal. Mains adaptor included.

- Video input: YPbPr (component)
- Audio input: Coax digital or optical
- Supports HD resolution up to 1080p
- Dimensions: 90(L) x 68(W) x 25(H)mm

AC-1607 WAS $129.00

$109.00 SAVE $20*

KEYSTONE WALLPLATES & FITTINGS

Keystone Wall Plate Single White

Flush type wall plates to accept our standard keystone 110 jacks. Fits standard Australian electrical switch plate installation hardware and screw centres, making it perfect for easy flush installation on plasterboard or other cavity walls.

- Supplied unloaded without keystone jacks
- Dimensions: 70(W) x 114(H) x 6(D)mm

FROM $2.50

Single White	YN-8050 $2.50
Double White	YN-8052 $2.50
Triple White	YN-8054 $2.75
Quad White	YN-8056 $2.90
6-Way White	YN-8058 $2.95

RCA - RCA Keystone Inserts Gold Plated

Range of inserts for audio/video applications. They fit standard 110 keystone wallplates.

Blue
PS-0794 $2.95

NEW 2011

Green
PS-0798 $2.95

See our website or ask instore for full keystone range

Keystone RJ Sockets

NEW 2011

- RJ11 Socket 6P4C **YN-8026** $4.95
- RJ12 Socket 6P6C **YN-8027** $4.95
- RJ45 Cat5E **YN-8028** $4.95
- RJ45 Cat6 **YN-8029** $4.95

Recessed Cable Entry Wall Plates

Create a neat cable entry/exit point for terminated or non-terminated audio and video leads. The wallplate design allows cables to be passed through walls with minimal fuss and the inner curved recessed design ensures maximum safety. Mounting screws included.

- Screw thread size: 2.5mm

Small PS-0295 $6.95
Large PS-0297 $6.95

NEW 2011

4 COLOUR LIGHT CHASER

Features a built in sound modulator, which flashes the lights in tune with the beat. It uses 240V 60W ES reflector lamps, and is supplied with a red, yellow, green, and blue globe. Mains powered and housed in a strong metal case. Includes mounting bracket and 800mm mains lead.

- Dimensions: 435(W) x 105(H) x 185(D)mm

SL-2942

$79.95

Spare globes available separately

Orange	SL-2953	$9.95
Purple	SL-2954	$9.95
Red	SL-2955	$9.95
Green	SL-2956	$9.95
Blue	SL-2957	$9.95
Yellow	SL-2958	$9.95

Brighten up your next party!

75W STROBE LIGHT

This mains powered unit features a super bright 75W flash tube with a large reflector for the brightest light, an adjustable flash rate and a signal output for daisy chaining. Made from strong plastic and is supplied with mounting hardware.

- Supplied with an 800mm mains lead
- Designed for domestic use only
- Spare globe available separately **SL-2693** $12.95

$59.95 SAVE $30.00

- Dimensions: 230(L) x 200(Dia.)mm

SL-2999 WAS $89.95

LIGHTING STAND

This strong and sturdy lighting stand will extend from 1,530mm to 3,650mm and is designed to carry up to 20kgs on the square section cross tree. The stand has 4 bolts for attaching up to 8 Pin Spots or other attachments.

$99.00 SAVE $20.00

- Collapsible legs (extends up to 750mm)
- Finished in matte black

CL-2800 WAS $119.00

LASER LIGHT SHOWS

Red and Green Twinkle Laser Show

Basic economy model provides red & green twinkle laser light display. Sound activated, auto or remote control with variable modulation. Manually controlled only.

- Mains operated from 9-12VDC plugpack (included)
- Dimensions: 135(L) x 105(W) x 55(H)mm

SL-3439 WAS $149.00

$129.00 SAVE $20.00

DMX control available - Use SL-3429 WAS $149.00 NOW $109.00 SAVE $40.00

BUBBLE BLOWER WITH LED LIGHTS

Generates a fascinating display of bubbles that kids will love. Simply insert the included bottle of liquid bubbles into the reservoir and watch as it produces a consistent stream of bubbles with a click of the trigger.

- LED lights
- 100ml bubble liquid included
- Battery powered

AB-1230

$14.95

2WAY CEILING SPEAKERS

These 2-way ceiling speakers provide outstanding music performance. Featuring custom designed crossovers and high performance tweeters matched to the woofers, providing much better sound reproduction over the full music range.

Sold as a pair

- 8-ohm impedance
- White in Colour

FROM $79.00

6.5"

- Freq. Range: 70Hz to 20kHz
- Rated Power: 30WRMS

CS-2446 WAS $99.00 NOW $79.00 SAVE $20.00

8"

- Freq. Range: 50Hz to 20KHz
- Rated Power: 50WRMS

CS-2448 WAS $139.00 NOW $99.00 SAVE $40.00

LOW COST MICROPHONES

Dynamic, unidirectional microphones with an anti-pop grille, built-in on/off switch.

- Frequency response range: 50Hz - 13kHz
- Sensitivity: -50dB
- Output Impedance: 600 ohm

Unidirectional Dynamic Microphone

- Supplied with a fixed 3 metre lead with 6.5mm plug

AM-4190

$9.95

Unidirectional Microphone

- Supplied with a removeable 3 metre lead, XLR to 6.5mm plug

AM-4192

$14.95

AM-4192 shown

Red and Green DMX Laser Show

DMX controlled, red and green twinkle displays with spectacular high power blue LED waterfall effect. Adjustable dimmer, rotation speed and stroboscopic function.

$249.00 SAVE $50.00

- Brightness adjustment
- Scattering function
- Mains powered
- Dimensions: 200(L) x 85(W) x 158(H)mm

SL-3437 WAS $299.00

CREATE AN ATMOSPHERE

Green Laser Star Projector

Projects thousands of dazzling green laser star like formations and comes with an integrated amplified speaker to connect an iPod® or other music source. To complete the ambience, it also has colour changing LEDs which can be set to beat with the music or one of the four colours (red, green, blue and white).

- Laser colour: green
- Laser power: <1mW
- Amplifier: 6WRMS
- Dimensions: 140(L) x 140(H) x 110(D)mm

$79.00 SAVE $40.00

SL-2931 WAS $119.00

ILDA Animation Laser Show

ILDA (International Laser Display Association) capability enables full software integration and complex animation of your laser show. The unit comes with pre-programmed displays and characters, but with the use of ILDA software such as Zion®, Millennium® or VSD® you can add PC control to create cartoons, letters, figures or other characters. Software is not included.

- ILDA software or DMX control
- Control mode: Sound active, automatic, DMX (6 channels), master/slave
- Mains powered
- Dimensions: 270(L) x 80(W) x 174(H)mm

$369.00 SAVE $30.00

SL-3438 WAS $399.00

STAGE LIGHTING

Spotlight PAR36

This versatile, compact spot lamp uses PAR36 sealed beam pinspots and can be fitted with coloured gel caps (available separately) for multiple theatrical effects. Just point one of these at a rotating mirror ball for great effect.

Buy all 3 for $35 Save $12.65

- Globe not included (use SL-2964 $11.95)
- Dimensions: 140(L) x 115(Dia.)mm

$19.95

SL-2960

PAR36 Spotlight Lamp

6V 30W sealed beam bulb for our PAR36 pinspots (above) with screw on connection terminals.

$11.95

SL-2964

Pinspot Coloured Gel Cap Set

Designed for our PAR36 pinspot light (above) this set of 8 gel caps include yellow, red, light green, dark green, blue, purple, amber and rose pink.

$15.75

SL-2965

Limited stock on sale items. All Savings are based on Original RRP

TIME TO CELEBRATE

ACOUSTIC GUITAR WITH USB CONNECTION

A complete composition, arranging and recording package! Full size steel string acoustic guitar with laminated top and sides with built-in chromatic tuner and 3-band EQ. Directly interface to a PC via USB cable. The bundled recording software MAGIX Music Maker SE is one of the easiest and most intuitive programs around and will have you recording in seconds. Arrange, edit, build and mix tracks with intuitive, easy-to-use tools. Even the most inexperienced user of PC based recording will find it very easy to start recording tracks in seconds.

$199.00
SAVE $50

- No drivers required
- Compatible with Windows XP, Vista, 7
- Intuitive drag and drop software
- Requires 1 x 9V battery
- Mac compatible
- Spare strings available separately **CS-2558** $14.95

CS-2559 WAS $249.00

LED STROBE LIGHT WITH MAGNETIC BASE

Portable LED flashing strobe light with a magnetic base which can be placed on any iron/steel surface. Great to spruce up any party or just to attract attention at any shopfront window. Battery operated or use with a 4.5VDC 200mA mains plugpack (Use **MP-3310** $19.95). Available in red, blue or amber.

BUY ANY 2 FOR $30.00!

- Requires 3 x AAA batteries

Red	**SL-3325**	$22.95
Blue	**SL-3327**	$22.95
Amber	**SL-3329**	$22.95

$22.95 ea.

40W BLACKLIGHT FLUORO TUBE

Used extensively for live music, discos, night clubs, and great for parties. Requires standard 40W fluoro fitting.

- Dimensions: 1225 (L) x 25 (Dia)mm

$19.95
SAVE $10

SL-3152 WAS $29.95

2 X 100WRMS STEREO AMPLIFIER WITH REMOTE CONTROL

Rated at a generous 100WRMS per channel and has a flat frequency response from 20Hz to 20kHz. Bass and treble controls are fitted providing +/- 10dB cut or boost. Equipped with microphone input level control, an infrared remote control and screw-down speaker terminals to firmly secure the speaker cables.

- 6 to 8 ohm output impedance
- Inputs for Tape, Tuner, AV1, AV2, CD, Phono
- Input impedance 47k ohm
- Tape Out level - 250mV
- Dimensions: 420(W) x 135(H) x 214(D)mm

AA-0470 WAS $199.00

$179.00
SAVE $20

WIRELESS MICROPHONE UHF DUAL CHANNEL

A two-channel system supporting two separate microphones. Each channel has a separately balanced XLR output. A single unbalanced (mixed) line output is also available. The system includes two microphones and batteries, receiver unit, plugpack and one metre 6.5 mono plug to 6.5 mono plug lead.

$149.00
SAVE $50

Microphone/transmitter
- Frequency range: UHF
- Range: 60m

Receiver
- Frequency response: 40Hz - 18kHz
- Power: 4W
- Dimensions: 210(L) x 170(D) x42(H)mm

AM-4078 WAS $199.00

CELEBRATING 30 YEARS OF SERVICE

JAYCAR'S 30TH YEAR! Spend $300 on products from pages 4 or 5 and get $30 OFF!

JV60 SPEAKER KIT

With the return of the VIFA drivers, we are proud to re-introduce the JV60 speaker kit. By investing a couple of hours of your own time to build this superb system to compliment most mid-powered amplifiers/receivers and save hundreds over commercial speakers. Kit is sold in two parts; speaker components with mounting accessories and pre-built speaker cabinets.

FROM $199.00

Place your order in-store and we'll build it for you!

JV60 Speaker Kit with Crossovers & Accessories - Pair

- Speaker kit includes woofers, tweeters, crossovers and mounting accessories
- 4 x 6.5" VIFA P17WJ (see CW-2106 for specs)
- 2 x VIFA D35AG (see CT-2020 for specs)
- 2 x 3-way, Linkwits-Riley crossover

CS-2560 $499.00

JV60 Prebuilt Cabinets - Pair

- Bass reflex design with corner frequency of 35Hz
- Pre-built with all holes cut out for components
- Finished in "blackwood" veneer
- 1090(H) x 250(W) x 260(D)mm 50L internal volume

CS-2562 $199.00

Pre-assembled JV60 Complete - Pair

We are also offering a fully assembled version if you just don't have the time but still want to experience the quality performance of this design.

CS-2564 $899.00

15" PARTY SPEAKERS

This rugged party speaker handles 120WRMS driven by amplifiers with modest outputs and are protected against over powering by a PTC speaker protector. Covered in a black hard wearing carpet with plastic corner protectors.

- 1 x 15 inch woofer
- 3 x piezo tweeters
- 1 x wide dispersion piezo horn
- Weight 25.5kg
- Dimensions: 740(H) x 505(W) x 350(D)mm

$179.00

Buy 2 for $300 SAVE $58

CS-2515

DJ ESSENTIALS

2 Channel Pro DJ Mixer

The ideal mixer to learn on. Two channels each with RCA inputs for CD or other line level source and a set of dedicated phono inputs. The BPM counter is capable of accurately measuring the beats per minute of almost any kind of dance music automatically and works equally well with a CD player or a turntable.

$149.00

- Level meters on each channel
- 2 band EQ on each channel
- Phono and line level inputs
- Mic and headphone outputs
- Effects loop
- Line level preamp outputs
- Selectable CF curve
- Dimensions: 330(W) x 22(H) x 102(D)mm

AM-4206

DJ Mobile 19" Rack Frame

Completely portable! Ideal for DJs, PA techs, sound engineers or guitarists with large rack setups. The top section can be rotated through a range of 45° for maximum flexibility. 6mm screws and captive nuts included. Sturdy steel construction with castors.

- Dimensions: 530(W) x 1050(H) x 500(D)mm

$99.00

HB-6348

NOTE: Equipment not included

DJ Single Headphone with Handle

Closed back, single cup headphone, designed especially for DJs. Keeps one hand available and frees you up from the constraints of wearing headphones. Curly cord cable terminates to 6.5mm plug.

- Driver diameter: 50mm
- Impedance: 48 ohms
- Sensitivity: 98±3dB
- Frequency response: 15Hz - 20kHz

$29.95

AA-2059

LED Gooseneck Mixing Desk Light

No DJ or engineer should be without one of these. Plugs into any XLR microphone socket with phantom power and provides enough light to see what you're doing without disturbing the audience. Solid gooseneck and LED globes.

- Runs on phantom power
- 400(H)mm

$24.95

AM-4124

NOTE: Mixer not included

Better, More Technical

All Savings are based on Original RRP
Limited stock on sale items.

To order call 1800 022 888

CREE® LED POWERED TORCHES

This range of CREE® LED torches are all encased in rugged aircraft-grade aluminium that will withstand rigours and constant use. Delivers 90 to 190 lumens of white light on the maximum setting. Multiple light modes are available for any situation. All splash resistant and includes carry strap.

FROM $14.95

90 Lumen

- Burn time: 1 hour
- Requires 1 x AA battery
- Dimensions: 95(L) x 20.5(Dia.)mm

ST-3452 WAS $19.95 NOW $14.95 SAVE $5.00

170 Lumen

- Burn time: 1 hour
- Requires 2 x AA batteries
- Dimensions: 147(L) x 20.5(Dia.)mm

ST-3454 WAS $24.95 NOW $17.95 SAVE $7.00

190 Lumens

- Burn time: 2 hours
- Requires 1 x CR123A Li-ion battery
- Dimensions: 73(H) x 21(Dia.)mm

ST-3450 WAS $24.95 NOW $19.95 SAVE $5.00

HALOGEN SPOTLIGHTS

3 Million Candlepower Rechargeable Halogen Spotlight

Provides 20 minutes continuous operation with 3,000,000 candlepower will be plenty of light for any outdoor activity. Ideal for rescue, shooting, fishing or boating. Rechargeable via mains or car cigarette lighter socket (both included).

- 55W halogen
- Built-in SLA battery
- Locking on/off switch
- LED map light
- Replacement globe SL-3221 $5.95

$29.95

ST-3301

Also available: 5 Million Candle Power Rechargeable Spotlight with Swivel Handle **ST-3303** $39.95

CREE® LED ADJUSTABLE HEAD TORCH

Three modes of operation - high, low & strobe. Can be focused quickly from wide to spot by simply sliding the zoom in or out. Comfortable elasticised head strap. Ideal for camping, caving, fishing etc.

- Max output: 180 lumens
- Burn time: 8hrs
- Water resistant
- Requires 3 x AAA batteries

$39.95

ST-3279

CYCLIST ACCESSORIES

LED Indicator Strap for Cyclists

Gives a clear indication to motorists when turning left or right on the road with this bright LED indicator light that can be strapped around your waist or to the bike with a wireless controller. The LED strap uses 28 powerful LEDs that will be easily visible in the dark or in low light/foggy environments.

NEW 2010

$29.95

- Hazard mode
- Requires 3 x AAA batteries
- Dimensions LED lights: 257(L) x 119(W)mm Controller: 56(L) x 45(W) x 19(D)mm

ST-3226

EMERGENCY DEAL

Rechargeable LED Work Light with Torch

A robust LED work light with a magnetic base and hanging hook which makes it ideal for emergencies or boating and camping etc. It has a 30 LED work light mode and a single LED torch mode. Mains plugpack and car charger included.

$39.95

- Up to 8 hours burn time
- Anti-slip finish
- Dimensions: 360(L) x 55(Dia.)mm

ST-3024

Buy both & get $30 OFF!

5-in-1 Jump Starter-Inverter-Charger-Compressor-Work Light

Pop one in the boot of your car for emergencies. The internal 12V 18Ah SLA battery can be used for jump starting or to power the 400W inverter. It has 2 x 12VDC cigarette lighter sockets for operating 12V appliances, 5 LED work light and a 260PSI air compressor with air hose for inflating tyres or air beds etc. Dial indicators on the front panel indicate air pressure and charge status. Mains and car chargers included.

- Built in air cooling fan
- Battery level indicator
- Charging and air compression dial indicators
- DC charging takes approximately 12 hours
- AC charging takes approximately 34 hours
- Charging jack
- Dimensions: 220(L) x 215(W) x 295(H)mm

MB-3594

$149.00

EMERGENCY CAUTION LIGHT

Compact and visible up to 800 metres away, this super strength plastic caution light contains a strong magnet for placement on vehicles in an emergency situation. With built in IC controlled LED flash, this light has 9 user-selectable flash patterns: rotate, double blink, single blink, alternative, SOS for rescue, solid-on high and low, and 2 and 4 LED flashlight.

- Requires 2 x AAA batteries (use **SB-2426** $1.95)
- Dimensions: 105(Dia.) x 35(H)mm

$19.95

ST-3201

BUY 2 FOR $30 SAVE $9.90

LED Bike Light Kit

Outputs 190 lumens and has an adjustable focus beam. Mount the torch onto 25 to 31mm handlebars with the adjustable bracket or detach to use as a conventional torch. The kit also includes an ultra-bright rear safety light with flashing and continuous modes. Designed to clip onto your belt, bicycle saddlebag or back pack.

Headlight/torch:

- Requires 3 x AAA batteries
- Dimensions: 105(L) x 32(Dia)mm

Taillight:

- Requires 2 x AAA batteries
- Dimensions: 60(L) x 35(H) x 25(D)mm

$39.95

ST-3465

38 CHANNEL UHF CB TWIN PACK

These mini UHF CB communicators (sold as a pair) can keep you clearly in touch with the kids at up to 3km range! Perfect for camping, picnics in the bush, skiing and hiking trips. Features an electronic volume control, monitor functions and an integrated LED torch. Comes in a child friendly package and supplied in orange and green units.

$29.95 Save 25%*

- 38 Channels
- Push to Talk (PTT) function
- Low battery alert
- Duplex range extender
- Requires 3 x AAA batteries per unit
- Dimensions: 55(W) x 110(H) x 35(D)mm

DC-1005 WAS $54.95

*Limited stock

Also available
38 Channel Rechargeable Handheld 0.5W CB Pair with charging cradle.
DC-1007 WAS $69.95 NOW $39.95 SAVE $30.00

HELICOPTERS

Mini Apache 2 Ch IR Helicopter

An entry-level chopper for the first time flier. 2 channel means you don't have too many controls to think about so you'll be up and flying in no time. Robust moulded plastic construction to take the inevitable bumps and occasional crash. Recharges directly from the remote unit.

- 20 minutes charge gives about 10 minutes flight time
- Remote requires 6 x AA batteries
- Size: 160(L)mm approx.
- Recommended for ages 10+

$24.95

GT-3273

Buy 2 of GT-3273 for $40.00 SAVE $9.90

Apache 3-Ch RC Attack Chopper

With a built-in gyroscope, this chopper is very stable in flight and easy to control. Complete with chain gun and rocket pods, so start your own lounge room war today.

- 60-70 minutes charge gives about 10 minutes flight time.
- Remote requires 6 x AA batteries.
- Size: 310(L)mm approx.
- Recommended for ages 10+.

$59.95

GT-3382

Buy GT-3382 and receive GT-3273 FREE (valued at $24.95)

4 Channel RC Helicopter

Our most advanced helicopter yet. Elevation, yaw, pitch and bank (or for the lounge room hack - up, down, forward, back, bank left, bank right and left/right rotation). That means you can fly like a true chopper ace with all the moves and tricks.

- 90 minutes charge gives about 10 minutes flight time

SAVE $40.00

- Chopper battery: 7.4V Li-Po 850mAh
- Frequency: 2.4GHz
- Remote unit requires 8 x AA batteries
- Size: 360(L)mm
- Recommended for ages 10+

GT-3340 WAS $179.00

FOR THE CAR

IN-CAR ENTERTAINMENT

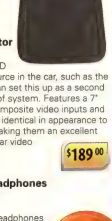
7" TFT Colour Monitors with Headrest & DVD Player

This system not only plays DVDs, but also your video files such as DivX, MPEG4, etc, and even play videos on your USB stick or SD card. You can also connect an Xbox360® or Playstation3® via the AV input. Includes an in-built games system (games CDs included), two games controllers and IR remote control.

- Resolution:1440 x 234 (16:9/4:3 selectable)
- System: NTSC/PAL
- Power: 12VDC
- Supports infrared earphones (AA-2047 below)
- Supports USB/MS/MMC/SD card
- Dark grey leather-look upholstery
- Headrest dimensions: 280(W) x 200(H) x 110(D)mm

QM-3776

$229.00


QM-3776 shown

7" TFT Colour Monitor with Headrest

If you already have a DVD player or other video source in the car, such as the QM-3776 (above) you can set this up as a second or third monitor as part of system. Features a 7" TFT screen, with two composite video inputs and IR remote control and is identical in appearance to the QM-3776 (above) making them an excellent "pair" for a complete in-car video entertainment system.

QM-3766

$189.00

Wireless Stereo Headphones - Suits QM-3776/66 Headrests

Add a pair of wireless headphones to suit your colour monitor headrest (above) and enjoy automotive bliss. Soft cushioned earpads for comfort, switchable between channel A and B.

BUY QM-3776 or QM-3766 & get AA-2047 FREE!

- Driver diameter: 27mm
- Nominal impedance: 32 ohms
- Frequency response: 120Hz - 20kHz

AA-2047

$39.95

2.4GHz REAR VIEW MIRROR REVERSING CAMERA

Incorporates a reversing camera which can be mounted internally or externally and transmits video signals via the 2.4GHz band to the monitor. The monitor fits securely over your existing rear view mirror and can be quickly removed when needed.

- 3.5" LCD colour screen
- Range: up to 80m
- Dimensions: 280(L) x 95(H) x 26(D)mm

QM-3795

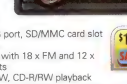
$199.00

IN-DASH MULTIMEDIA PLAYER WITH USB AND BLUETOOTH

Complete with flip-down and detachable panel with colour LCD and slimline remote control.

- Bluetooth file sharing & handsfree mobile phone capability
- Front USB port, SD/MMC card slot and aux-in
- PLL tuner with 18 x FM and 12 x AM presets
- DVD±R/RW, CD-R/RW playback
- 4 channels x 20WRMS output (40WRMS max)
- 4-band equaliser (classic, pop, rock, flat)

QM-3788. WAS $249.00



$199.00 SAVE $50.00

3.5" LCD Car Dash-Mount Colour Monitor

Mounts onto vehicle's dashboard and partners with any video source such as a reversing camera or a DVD player for in-car entertainment. The rear vision view is automatically activated when the reversing gear is engaged. Includes adjustable swivel bracket and sunshade.

- Two composite video inputs
- Automatic mirror image selector for reversing cameras
- Powered by 12VDC
- Dimensions: 100(W) x 87(H) x 26(D)mm

QM-3792

NOTE: Camera sold separately

$79.00

5" LCD Monitor with Reverse Camera Kit

Affordable all-in-one reversing camera kit. Includes a slimline 5" LCD monitor, a powerful suction mount bracket, and a tiny reversing camera to be mounted at the rear of the vehicle. The camera docks securely in the bracket but can be easily popped out and put in your glove box so as not to tempt potential thieves.

- Dimensions: LCD: 127(L) x 82(W) x 15(D)mm Bracket: 133(H) x 65(Dia.)mm

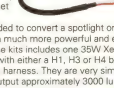
QM-3741

$249.00

CAR HEADLIGHTS LIGHTING

Single HID Conversion Kits - 35W

These are a simple single version of a High Intensity Discharge (HID) headlamp that you are now seeing on up market cars. They are one lamp set only. They are basically intended to convert a spotlight on, say a large boat, to a much more powerful and effective spotlight. These kits includes one 35W Xenon HID lamp, 6000K, with either a H1, H3 or H4 base, ballast unit and wiring harness. They are very simple to install. Light output approximately 3000 lumens at 12V.



Kits to suit H1, H3 and H4 bases available:

$49.95 SAVE $20.00

H3	**SL-3365**	WAS $69.95
H1	**SL-3367**	WAS $69.95
H4	**SL-3368**	WAS $69.95

WARNING: State Road and Traffic Authorities do not allow retro-fitting of these products to cars with ordinary headlights - even though these kits do not require any changes to factory wiring.

REVERSE PARKING ASSIST KITS

Wireless Digital Vehicle Parking Assist System

Park your car with the same ease as the newest models using this ultrasonic reversing system. The 4 sensor system allows you to see both the distance and direction to an object, and installation is a breeze with no wires from the controller at the back to the dashboard display. Kit includes 4 flush mount sensors, controller with wiring, and LCD display.

$129.00

- Power: 12VDC
- Display Dimensions: 72(L) x 53(W) x 17(D)mm
- Sensor Dimensions: 23(L) x 21(Dia)mm

LR-8874

Front and Rear Parking Assist Kit

While most reversing systems cover the rear of a vehicle they do nothing for the blind spot on the nose. This system covers both areas with 4 sensors making it ideal for squeezing into a tight parallel park or parking in a short carport or garage. The LCD display clearly indicates the distance to objects in both directions and an audible alarm sounds if you get too close.

$249.00

- Input voltage: 9-16VDC
- Display dimensions: 104(W) x 75(D) x 41(H)mm

LR-8872

3-STAGE 6/12V AUTOMATIC BATTERY CHARGER

Automatically diagnoses, recovers and recharges 6 or 12V lead-acid, gel, and AGM rechargeable batteries for boats, motorcycles etc. Extends battery life by constantly monitoring battery condition and bulk, trickle or maintenance charges accordingly.

$49.95

- Output voltage: 7.2, 14.4VDC
- Charging current: 750mA max
- Capacity: 1.2 - 20Ah
- Dimensions: 110(L) x 62(W) x 45(H)mm

MB-3603

Dual Lamp HID Conversion Kits - 35W

Used in the latest model luxury and high performance cars, High Intensity Discharge (HID) vehicle headlights are far brighter, whiter and more efficient than their quartz halogen predecessors. These HID dual lamp conversion kits are suitable for H4 bases.

SAVE $30

FROM $69.00

- 35W HID Xenon lamps
- 6000K colour temperature comparable to sunlight
- Extra bright 3200 lumens

Available in two easy-installation models:

HID Xenon Low Beam SL-3416
WAS $99.00 NOW $69.00 SAVE $30.00

HID Xenon High/Low Beam SL-3417
WAS $149.00 NOW $119.00 SAVE $30.00

Replacement Bulb SL-3414 sold each
WAS $39.95 NOW $29.95 SAVE $10.00

Replacement Ballast SL-3418 sold each
WAS $49.95 NOW $39.95 SAVE $10.00

Sold as a pair!

CELEBRATING 30 YEARS OF SERVICE

HAPPY BIRTHDAY SALE

November 2011

Spend $30 or more from our Happy Birthday flyer & receive a collector's edition stubby holder FREE!

SNOW MACHINE

Make a storm with your very own snow machine! The machine sprays a jet of snow particles into the room adding an extra dimension to a party or entertainment event. Snow particles dissipate into the air. Features a versatile mounting bracket and wireless remote control to trigger the snow.

- 240VAC operation
- 1 Litre fluid capacity (Snow juice sold separately **AF-1217** $14.95)
- Dimensions: 337(L) x 260(W) x 227(H)mm

AF-1216

NEW 2011

$99.00

9" LCD MONITOR WITH 4 VIDEO INPUTS

Versatile 9" colour video monitor with 4 composite video inputs. Inbuilt multi-signal controller can display 1, 2, or 4 inputs simultaneously. Ideal for vehicles with multiple cameras for reversing and manoeuvring. Swivel mounting bracket can be adjusted to any angle and can also be adapted for ceiling mounting.

NEW 2011

- 680 x 480 pixel display resolution (16:9 format)
- 4 x composite video inputs
- 1 x composite video output
- 12-24V DC powered
- Overall dimensions: 236(W) x 158(H) x 27(D)mm

QM-3794

$299.00

REVERSING CAMERA WITH SENSORS AND 3" LCD MONITOR

This complete reversing system includes a flush mount camera, 3" LCD screen and 4 sensor ultrasonic distance system. The screen shows the camera vision together with sensor status and parking assistance lines. The distance to sensed objects appears in the screen and an audible alarm sounds if you get too close to anything.

$249.00

More parking sensors on page 2

- Power: 12VDC
- On Screen Display menu
- Flush mount camera included
- Shock, vibration and water resistant camera
- Dimensions: Screen: 93(W) x 62(H) x 24(D)mm Camera: 33(L) x 20(Dia.)mm

LR-8870

NEW 2011

CAIRNS STORE RELOCATION

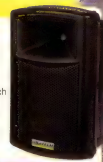
153 Mulgrave Road
Cairns 4870
Ph: (07) 4041 6747

Parking Available!

BIRTHDAY DEAL

12" Party Speaker

This speaker can handle a massive 200WRMS and is an excellent addition to any entertainment equipment range. It provides good performance in locations such as backyards, tents, party rooms or halls etc. Moulded from high impact resin and the main driver is protected by a tough metal grille.



- 1 x 12 inch woofer
- 1 x wide dispersion piezo horn
- Weight: 16kg
- Dimensions: 620(H) x 400(W) x 330(D)mm

CS-2514

$249.00

Dual Channel / Bridged 400W Rack Mount Amplifier

A cost effective rack mount amplifier suitable for a variety of pro-audio applications, including running two 12" speakers shown above. Has 1/4" jack RCA and balanced XLR inputs. Also features solid aluminium chassis and front level controls.

$299.00

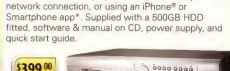
- Power output: 2 x 200WRMS @ 4 ohms, 1 x 400WRMS bridged @ 8 ohms
- Dimensions: 480(W) x 90(H) x 247(D)mm

AA-0479

Buy 2 x CS-2514 & 1 x AA-0479 for $700 SAVE $97

4 CHANNEL H.264 NETWORK DVR WITH D1 RESOLUTION

An economical digital video recorder which incorporates a 4 channel multiplexer, Ethernet functions, H.264 video compression, and even delivers D1 resolution video (704 x 576 pixels) at 100 frames per second. Use it to record up to 4 cameras simultaneously with playback available locally, via a network connection, or using an iPhone® or Smartphone app*. Supplied with a 500GB HDD fitted, software & manual on CD, power supply, and quick start guide.



$399.00

- Video compression format: H.264
- Recording Resolution: 352 x 288 (CIF) 704 x 576 (D1)
- Max Recording Frame Rate: 100 IPS
- Hard disk storage: 500GB SATA
- Dimensions: 343(W) x 240(D) x 68(H)mm

QV-8107

500GB HDD Included!

NOTE: *Free application available to view live footage. Application based searching and backup requires advanced version at an additional cost.

QV-8107

GRID-CONNECT SOLAR POWER MONITOR WITH USB INTERFACE

Measures the power consumption of your home, the power being produced by solar array, and also gives a "balance" of the power consumed versus what the solar array is producing. It displays the costs, with 3 tariffs and a feed-in tariff. Incorporates two wireless transmitters with sensors and indoor display. Each wireless transmitter is powered by 2xC batteries (included) whilst indoor display is powered by the included 240V AC adaptor or 3 x AAA batteries (not included) for backup power.

- Uses 433MHz to wirelessly transmit data
- Displays solar power, household power, costs, overall power and costs

MS-6167

NEW 2011

$179.00

NOTE: Only works with NET-METER grid-connect solar systems.

ULTIMATE "SPY" WATCH CAMERA

Looks just like a rugged aviator style wristwatch but features a hidden camera to record video and audio in AVI format (640 x 480 resolution) for up to 60 minutes or approx 1200 still pictures. Downloads and charges via the supplied 2.5mm to USB lead.

- USB driver software included
- Gift boxed
- Watch bezel size: 42(Dia.)mm

QC-8014

NOTE: Not waterproof

NEW 2011

$69.95

More covert surveillance on page 6

Video Online

12W DMX REVOLVING LED LIGHT

This feature packed and powerful revolving LED light has advanced moonflower effects with high power 3W red, green, blue and white LEDs which offer colour changing and colour mixing beams. Equipped 7 Channel DMX 512 programming or linking capabilities, built-in sound modulator, a step motor and strobe speed adjustment.

- 7 DMX Channels (Colour, Rotation, Rotation Speed & Strobe/Dimmer)
- Control mode: Sound Active, Master/Slave or DMX-512
- Mains Powered
- Dimensions: 216(W) x 198(H) x 135(D) mm

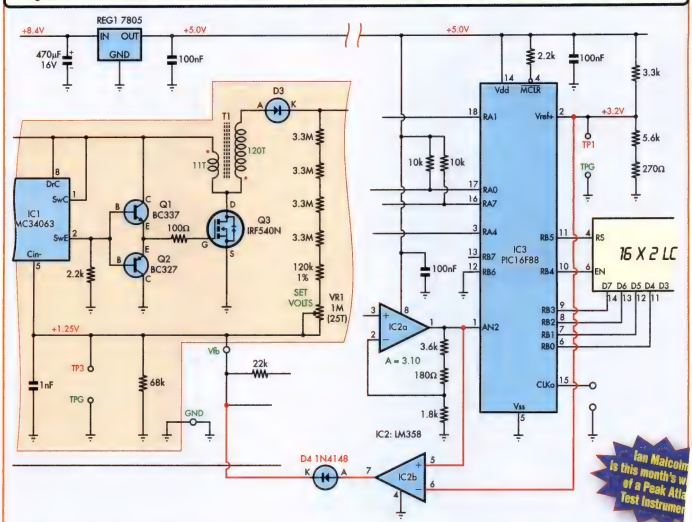
SL-2899

NEW 2011

$169.00

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Upgrade for the Digital Insulation Meter

The Digital Insulation Meter described in June 2010 allows the insulation of mains-powered equipment to be tested with up to 1000VDC. But if the outputs are accidentally shorted, it can potentially be damaged; the 4.7kΩ 1W current-limiting resistor is the most likely casualty.

But there's a simple change which can be made that protects this resistor (and other components) and reduces the battery drain in case of a short circuit (or a near-short). Just one additional diode (D4, a 1N4148) is required.

If a lot of current is drawn from the output (as in the case of a short circuit between the output terminals), the current feedback signal to pin 1 (AN2) of microcontroller IC3 will go much higher than usual.

In the original design, op amp IC2b was unused. For the upgrade, it is used as a comparator. It compares the feedback voltage to the +3.2V reference voltage at Vref+ (pin 2 of IC3). Should the feedback voltage go above this level, IC2b's output goes high and diode D4 becomes forward-biased, delivering current to the other feedback divider and so increasing the voltage at pin 5 of IC1, the MC34063 switchmode regulator.

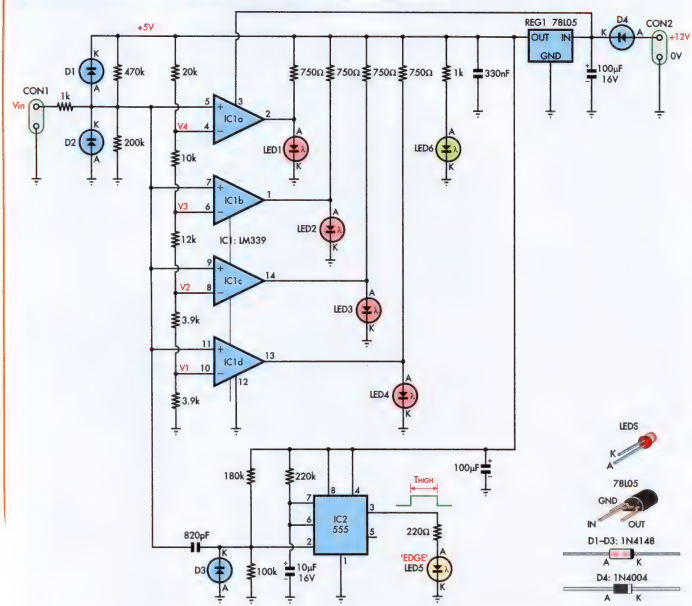
This is the feedback voltage and so IC1 responds by lowering Q3's duty cycle, reducing the regulated output voltage and so limiting the output current. This is the same response it would take if the output voltage were to go too high (which would also increase the feedback voltage).

The result is that the output current is limited to about 10mA under short-circuit conditions. This does not affect the meter reading as the voltage at AN2 is still above Vref+ and so the meter still shows 0MΩ.

If you want to modify the PCB make cuts around pins 5 & 6 of IC2, disconnect those pins from ground and then run thin wires between those pads and pins 1 & 2 of IC3. The 1N4148 can then be trimmed and soldered to pin 7 of IC2 and a flying lead run to IC1 on the separate board.

Ian Malcolm,
Melbourne, Vic.

Ian Malcolm is this month's w of a Peak Atla Test Instrume



5-level logic probe

This logic probe indicates five different voltage levels using four threshold voltages. This can make debugging logic circuits easier. It is optimised for use in circuits running from 3.3V but can be adapted for other supply voltages.

It also has an edge detector, to show when the logic level is changing, which may happen so fast that you couldn't otherwise see it.

For the circuit shown, the voltage levels indicated are 0-0.4V, 0.4-0.8V, 0.8-2V, 2-3V and 3-6V. When the probed voltage is below 0.4V, LEDs1-4 are off. For 0.4-0.8V, LED4 is lit while for 0.8-2V, LEDs3 & 4 are lit and so on, up to 3V where all four LEDs are on.

In other words, LEDs1-4 act as a bargraph, to show the approximate voltage being sensed.

The reason that having these thresholds can be handy is that if there is a bad solder joint or other problem in the circuit, some nodes which should be close to 0V or 3.3V may actually be at intermediate voltages and that may not result in reliable operation. By using this logic probe, you can easily find those problematic points in the circuit.

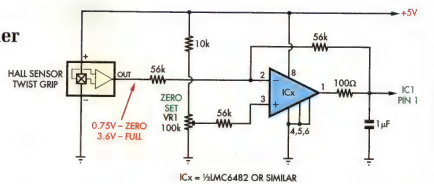
If the probed point is at a logic low (ie, close to 0V), LEDs1-4 will all turn off while if it is a logic high (ie, close to 3.3V) they will all be lit. If the probed track is at a high impedance (or the probe is not connected to anything), LEDs3-4 will be lit. If the line is being pulled low but not low enough to reliably register as a logic zero, only LED4 will light and similarly if it is being pulled high but not high enough to reliably register as a logic one, LEDs2-4 will light up but LED1 will not.

It works as follows. The probe connects to CON1 and the test voltage is

Twist-grip throttle for the 12/24V 20A speed controller

This circuit was devised to adapt the 12/24V 20A Speed Controller (SILICON CHIP, June 2011) to a twist-grip Hall Effect throttle in an electric quadricyle. This was run at 36V instead of 24V to drive a 36V 750W motor. This was possible without upgrading the Mosfets or the Schottky diode but extra supply filtering was required to suppress motor hash.

The twist-grip throttle uses a Hall effect device which gives an output ranging from +0.75V at rest position to +3.6V when full on. This needed to be changed to suit the TL494 on the Speed Controller PCB which needs an input voltage which ranges from +0.7V for full motor speed up to about +3V for zero speed.



The solution is this circuit which employs an LMC6482 or similar rail-to-rail op amp as a unity gain inverter. The offset adjustment provided by the 100kΩ trimpot VR1 enables the zero speed setting from the twist-grip throttle to be precisely set.

The circuit is supplied from the 5V output at pin 14 of the TL494 and the output of the LMC6482 connects to pin 1 of the TL494. It can be connected via CON2 on the Speed Controller PCB. To do this, VR2 and the 1kΩ resistor should be replaced by links.

Clifford Wright,
Helensville, NZ. ($45)

applied to the non-inverting inputs of comparators IC1a-IC1d, via a 1kΩ protection resistor. Diodes D1 and D2 clamp this voltage to be within a range of -0.7V to +5.7V, to protect IC1 from damage. The 470kΩ and 200kΩ resistors provide a bias of 1.5V but this only affects the sensed voltage when the source is high impedance.

IC1a-IC1d each compare the sensed voltage to a reference voltage derived by a string of resistors across the 5V rail. These nodes are labelled V1-V4 and are nominally 0.4V, 0.8V, 2V & 3V respectively. If the sensed voltage is below the threshold applied to a given comparator, the output pin of that comparator goes low, sinking current from the connected 750Ω resistor and thus the associated LED (one of LEDs1-4) stays off.

If however the sense voltage is above the threshold for that comparator, the output does not sink current and so approximately 4mA flows from the +5V rail through the 750Ω resistor and LED, lighting it. LED6 is the power indicator and so this is lit as long as the power is on. It is driven at about 3mA, as determined by the 1kΩ series resistor.

IC2, a 555 timer, acts as the edge detector. If the line being probed is toggling, this is coupled to its trigger input via the 820pF capacitor. The 180kΩ and 100kΩ resistors bias the voltage at this input just on the edge of the trigger threshold so that even a low-amplitude AC signal will trigger the timer. D3 protects the input from negative voltages in case the AC signal has a high amplitude.

If it is triggered, its output goes high for period T_{HIGH}, set by the 220kΩ resistor and 10µF capacitor to around 2.5 seconds. This period can be changed by altering either value. When the output is high, it drives LED5 with around 14mA.

An external 12VDC supply is required to run the circuit, with D4 providing reverse-polarity protection. A 78L05 regulator provides power for the LEDs and a reference voltage for the divider string, to accurately set V1-V4. IC1, the quad comparator, runs directly from the 12V supply as its input common mode range only extends to within about 1.5V of V_{CC}. That way, any applied logic voltage (0-5V) stays within its valid input range (in this case, about 0-9.5V).

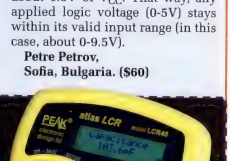
Petre Petrov,
Sofia, Bulgaria. ($60)

Contribute And You Could Win An LCR Meter

We pay for each of the "Circuit Notebook" items published in SILICON CHIP but there is another reason to send in your circuit idea.

Each month, at the discretion of the editor, the best contribution published will entitle the author to a nifty, compact LCR40 LCR meter, with the compliments of Peak Electronic Design Ltd – see **www.peakelec.co.uk**

So send that brilliant circuit idea in to SILICON CHIP and you could be a winner.



You can either email your idea to silicon@siliconchip.com.au or post it to PO Box 139, Collaroy, NSW 2097.

PICAXE-based digital RF meter

The Digital RF Meter described in SILICON CHIP in October 2008 did not appear in kit form and consequently, not having any means to program the PIC chip, I was unable to construct this project. Since I can program PICAXE chips I set myself the task of determining whether the project could be completed using the simplest PICAXE, the 08M. The 08M has a 10-digit ADC capability which is required in this project.

The first problem to be overcome was that the A-D conversion performed by the 08M uses its 5V supply as the reference whereas the original design uses a 3.5V voltage reference which is derived from the 5V supply. There is a very good reason for doing this and it relates to the inability of the LM324 chip (which drives the ADC input) to swing its output much higher than 3.5V when its supply voltage is 5V.

On the other hand, the LM324 can drive its output quite close to the 0V rail. Therefore, by using a 3.5V reference, the full range of the 10-digit A-D conversion is available.

Using an 08M with its 5V reference but only being driven to about 3.5V wastes a good deal of the resolution and range available. Hence the LM324 was replaced with an MCP6282 "rail to rail" op amp, which can swing its output to within about 15mV of the supply rails. This means the full range (almost) of the 5V reference can be used.

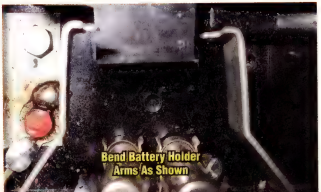
The second problem to be overcome was the number crunching. To calculate the dBV and dBm readings, exponential functions are required in addition to floating point arithmetic. This is well beyond the capabilities of a simple 08M so a desktop computer performs these calculations using a simple QBASIC program. The same cable that links the computer to the 08M for programming is now used to receive information from the PICAXE into the QBASIC program.

Since the output is displayed on the computer screen there is also no need for the 16x2 LCD module as used in the original project. Power for the device is obtained from the 12V supply in the computer or a 12V plugpack can be used, if preferred.

To give some measure of portability, a 0.5mA full-scale deflection meter salvaged from an old analog multimeter has been incorporated. This gives the device the ability to make comparative measurements as often this is all that's required. The meter has two sensitivity ranges and the reading can be nulled by trimpot VR4 to cancel unwanted background noise. In this situation, the unit could be powered by a 9V battery.

The circuit diagram shows that the header unit is identical to the original design. The DC output of the header unit is amplified by the MCP6282 and then applied to the ADC4 input of the 08M. Switch S1 provides six ranges. The ranges correspond to 10dBV, 0dBV, -20dBV, -40dBV, -60dBV and -80dBV.

S1b is connected to the ADC2 input of the 08M and provides information on which range has been selected. This information, together with the ADC value obtained from the RF signal, is encoded and sent to the computer running the QBASIC program. The QBASIC program receives this information over the



Battery replacement for an AVO Mk.8 multimeter

The revered British AVO multimeter employed a 15V battery which is now expensive and hard to obtain. I happened to be in one of the many $2.00 shops in NZ and spied a pack of five CR2032 cells for the princely cost of $2.00. Ensuring that they had a long expiry date, I purchased a couple of packs.

Five such cells gave 15V (16.7V actually), exactly what is required for the AVO. They were fitted into a 15mm length of 12mm (inside measurement) PVC conduit. You need to reshape the battery contacts as shown in the photo. It is then an easy task to fit the batteries, making sure you get the polarity correct. Finally, pack a little foam plastic, as per the photo, around the battery area.

Editor's note: using stacked lithium cells to provide 15V is a good idea when low current (<190µA) is required. The cells have a nominal 240mAh capacity down to 2V. CR2025 cells could also be used but are of a smaller capacity.

J. Barry Grumwald,
Kaitaia, NZ. ($20)

programming cable via the COM1 port. The data is decoded, the correct scaling factor applied according to the range selected, and the various quantities calculated and displayed.

The unit should be set up and calibrated as per the original article.

A couple of unanticipated problems were also encountered. It was found that for small input voltages, (those resulting in an ADC output from the 08M of less than about 20), the PICAXE did not accurately convert the analog voltage to its digital representation and the lower the voltage the worse the error became. However, ADC readings above about 20 invariably produced consistent readings all the way up to the maximum value of about 1017.

The maximum for 10-bit resolution should be 1023 and failure to reach this figure is probably a reflection on the inability of the MCP6282 to swing fully to the 5V rail. These shortcomings are more than compensated for by having six sensitivity ranges as opposed to three in the original article. The QBASIC program warns of potential errors due to low or high ADC readings and will suggest using another scale.

Note: use a recent PICAXE-08M as the older versions had errors which result in inaccurate ADC conversion results.

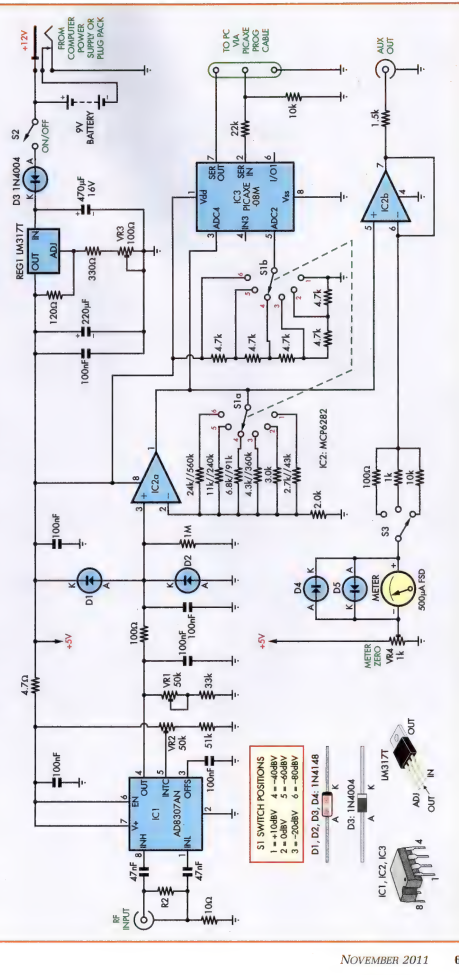
Again, even with no probe connected, the device shows a reading of about 42µV. With a probe connected this background reading is even higher.

To make reading a signal source easier, the QBASIC program allows the background reading to be subtracted and the difference displayed. So two complete sets of readings are displayed – the full reading including the background and the difference reading.

Note that later versions of Windows make it very difficult for programs such as QBASIC to access the serial and parallel ports. It worked satisfactorily with QBASIC and Windows XP.

Jack Holliday,
Nathan, Qld. ($60)

Footnote: the two software files are *rfmeterXPQB.bas* and *rfmeter08M.bas* and can be downloaded from the SILICON CHIP website.



Ultra-LD Mk.3 Stereo Amplifier . . .

Pt.1: By JOHN CLARKE & GREG SWAIN

Low-Noise Stereo Preamp With Motorised Volume Control & Input Selector

Designed for use with the Ultra-LD Mk.3 amplifier modules, this high-quality stereo preamplifier features a motorised volume control potentiometer. It is teamed with a 3-Input Selector board and both are controlled by the same infrared remote.

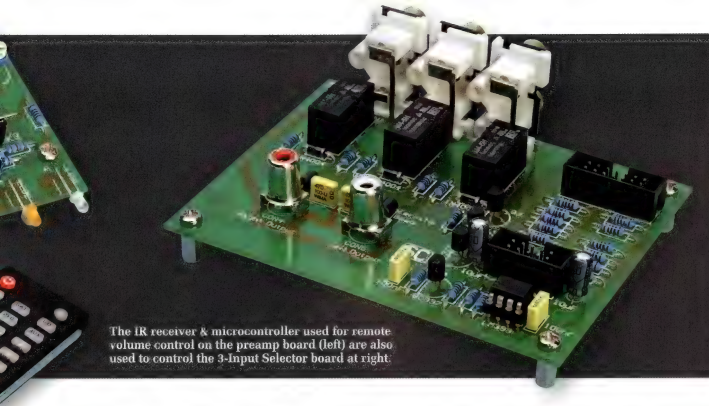
BY NOW, most readers will have realised that we intend describing a complete stereo amplifier in coming months, based on two Ultra-LD Mk.3 120W power amplifier modules. As well as the amplifier and power supply modules (July-September, 2011), we've also described the Loudspeaker Protector module (October 2011) and this month we are presenting the Preamplifier/Volume Control and Input Selector modules.

The preamplifier is a slightly modified (and improved) version of the circuit described in the August 2007 issue for our 20W Stereo Class-A Amplifier. It's a minimalist design delivering ultra-low noise and distortion.

The basic configuration was originally used our Studio Series Stereo Preamplifier described in October 2005. It employs a dual op amp IC in each channel, the first stage providing the gain and the second stage acting as a buffer for the volume control, to present a low output impedance to the power amplifier modules. In addition, the preamplifier PCB carries an infrared receiver, a PIC microcontroller and the motorised potentiometer to provide the remote volume control feature.

The PIC micro on the preamp PCB also provides the necessary decoding for the input selection. The resulting control signals are fed to a header socket and are coupled to a matching header socket on the Input Selector board via a 10-way IDC cable.

Also on the selector board are three stereo RCA input socket pairs, three relays to switch the inputs and a pair of



The IR receiver & microcontroller used for remote volume control on the preamp board (left) are also used to control the 3-Input Selector board at right.

internal RCA output sockets. The latter connect to matching input sockets on the preamp.

Performance

We have tweaked the already excellent August 2007 design for even lower THD+N (total harmonic distortion and noise) by making a few simple changes. Actually, while the changes are simple, the process of arriving at those changes was anything but simple and it took a a great deal of laborious testing of a number of prototypes as we gradually honed in on the final circuit configuration. The improvements in performance are mainly in the frequencies above 5kHz

Fig.7 plots the THD+N for bandwidths of 20Hz-80kHz and 20Hz-30kHz. As can be seen, the THD+N for 20Hz-30kHz (blue line) is generally less than 0.0007% all the way up to 9kHz and is still less than 0.0008% at 20kHz. And for 20-80kHz bandwidth (red), it's less than 0.0008% all the way up to about 16kHz, with just a very slight rise after that.

Those curves look excellent but that's not the whole story. As with the Class-A Stereo Amplifier described in 2007, we are limited by the residual distortion in our test set-up. The green line plots the THD+N of the sinewave generator in our Audio Precision test gear and it's only slightly below the THD+N plots for the preamplifier. For us to make an accurate distortion measurement, the residual distortion in the Audio Precision gear would have be -10dB (about one third) below that of the equipment to be measured.

So we really don't know how good the preamplifier is. It's so good that we cannot accurately measure it.

Note that while the above measurements may appear slightly worse than the 0.0005% quoted for the August 2007 design, the two sets of measurements were taken under different conditions. The original measurements were taken at full volume, while the latest measurements were taken at quarter volume which is more realistic given that CD & DVD players have a high output signal level. This also affects the signal-to-noise ratio and the separation between channels.

By any measure, this new design outperforms the original when it comes to THD+N and the other specifications are equally as good. The signal-to-noise ratio is better than -115dB, the channel separation is better than -87dB at 1kHz and the frequency response is virtually ruler flat from 20-20kHz. The accompanying specifications panel and the graphs show the details.

The circuit changes made to the original design and the resulting performance improvements are detailed in a separate panel. As well as these circuit changes, we also substituted vertical RCA sockets in place of the screw terminal blocks for the audio input and output connections. And of course, the preamplifier PCB now carries a header socket (in the remote control section) to interface with the Input Selector module.

Remote volume control

The remote volume control operation is straightforward. Press the "Volume Up" and "Volume Down" buttons on the remote and the pot rotates clockwise and anticlockwise. It takes about nine seconds for the pot to travel from one end to the other using these controls.

For finer adjustment, the "Channel Up" and "Channel Down" buttons on the remote can be used instead. These cause the pot shaft to rotate about 1° each time one of these buttons is briefly pressed. Alternatively, holding one of these buttons down rotates the pot from one end to the other in about 28 seconds.

If any of the buttons is held down when the pot reaches an end stop, a clutch in the motor's gearbox slips so that no damage is done.

Automatic muting is another handy feature. Press the "Mute" button on the remote and the volume control pot automatically rotates to its minimum position and the motor stops. Hit the button again and it returns to its original position. Don't want the pot to return all the way to its original setting? Easy – just hit one of the volume control buttons when the volume reaches the desired level.

Features & Performance

Main Features

- High performance design – very low noise and distortion
- Preamplifier module designed for the Ultra-LD Mk.3 Stereo Amplifier but can also be used in the Class-A Stereo Amplifier and with other power amplifier modules
- Remote input selection (three inputs) plus remote volume control (with muting) using a motorised potentiometer

Measured Performance

Frequency response	flat from 10Hz to 20kHz, -1.25dB @ 100kHz
Input impedance	~22kΩ
Output impedance	100Ω
THD+N	<0.001% (typically 0.0004%, 20Hz-20kHz BW)
Signal-to-noise ratio	-115dB
Channel separation	>87dB (>70dB @ 10kHz)
Preamplifier Gain	0-2
Output signal level	up to 8V RMS

Note: All measurements made at 1kHz, 2V RMS input & 1V RMS output, and 20-80kHz bandwidth

A couple of LED indicators – "Ack" and "Mute" – are used to indicate the status of the Remote Volume Control. The orange "Ack" (acknowledge) LED flashes whenever an infrared signal is being received from the remote, while the yellow "Mute" LED flashes while the muting operation is in progress and then remains on when the pot reaches its minimum setting.

So how does the unit remember its original setting during muting? The answer is that the microcontroller actually measures the time it takes for the pot to reach its minimum setting. When the Mute button is subsequently pressed again to restore the volume, power is applied to the motor drive for the same amount of time.

The input selection is controlled by pressing the "1", "2" & "3" buttons on the remote (for input 1, input 2 & input 3, respectively). Alternatively, the inputs can be selected by pressing the three buttons on a separate small Switch Board. An integral blue LED in each button lights to indicate the selected input.

The Switch Board connects to the Input Selector Board via a 14-way IDC cable and matching header sockets. So the Input Selector Board has two header sockets – one to accept the signals from the Switch Board and one to accept the remote control signals from the Preamplifier Board.

Preamplifier circuit

Fig.1 shows the preamplifier circuit details but only the left channel is shown for clarity.

The audio signal from the Selector Input board is AC-coupled to the input of the first op amp (IC1a) via a 22µF capacitor and 100Ω resistor, while a 22kΩ resistor to ground provides input termination. In addition, the 100Ω resistor, a ferrite bead and a 470pF capacitor form a low-pass filter. This attenuates radio frequencies (RF) ahead of the op amp input.

IC1a operates with a voltage gain of 2 (+6dB) by virtue of the two 2.2kΩ feedback resistors. The 2.2kΩ resistor and 470pF capacitor combination roll off the top-end frequency response, with a -3dB point at about 150kHz. This gives a flat response over the audio spectrum while eliminating the possibility of high-frequency instability.

IC1a's pin 1 output is fed to the top of volume control potentiometer VR1a (20kΩ log) via a 22µF non-polarised capacitor. The signal on its wiper is then AC-coupled to the pin 5 input of IC1b via a 4.7µF non-polarised capacitor.

The resistance of the pot affects the noise and distortion performance of the preamplifier and ideally a 5kΩ (or 10kΩ) pot would be used. However, a 20kΩ motorised pot is all that's readily available for now, so we've lowered the source impedance seen by the following stage (IC1b) by connecting a 4.7kΩ resistor between the pot's wiper and ground.

The compromise is that the response curve of the volume control is slightly altered. Fig.10 shows the simulated response curve of a shunted pot (red) compared to an ideal log pot (blue). As can be seen, the volume doesn't increase quite as quickly as it otherwise would for much of the pot's travel and then increases more rapidly right towards the end.

This isn't particularly noticeable in practice and just means that the pot has to be set slightly higher than normal for the same output level.

The effect of the shunt resistance on the noise and distortion (THD+N) is illustrated in Fig.11. As shown, the THD+N is reduced from about 0.001% to less than 0.0006% at 1kHz and from just over 0.003% to about 0.001% at 20kHz.

IC1b operates as a unity-gain buffer and provides a constant low-impedance output regardless of the volume control setting. Its pin 7 output is fed to output socket CON2 via a 22µF non-polarised capacitor and a 100Ω resistor to ensure stability. This resistor, together with the ferrite bead in series with the output, also attenuates any RF noise.

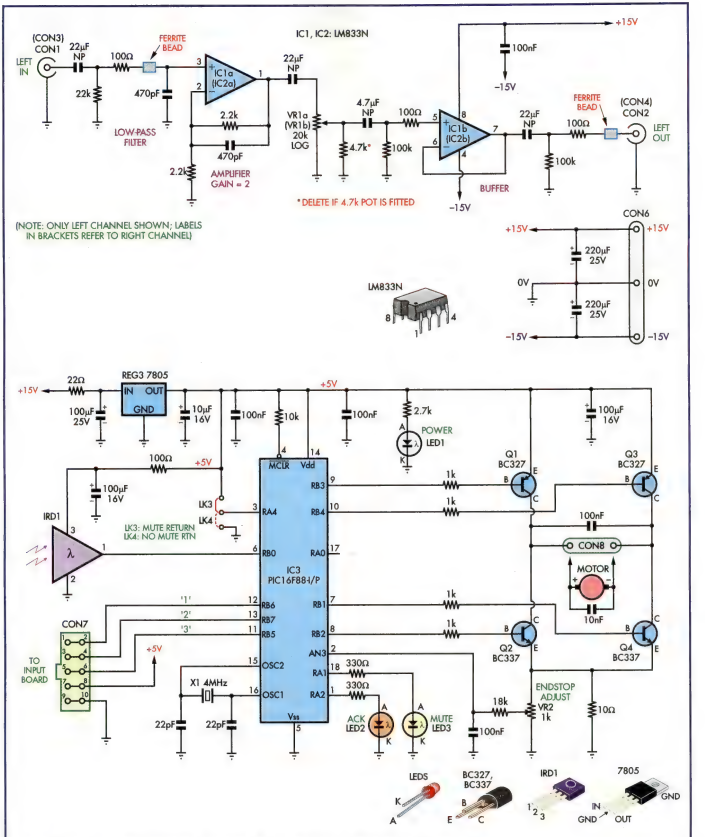
Power for the circuit is derived directly from the ±15V regulated outputs on the Power Supply board (described in September 2011). These ±15V rails are filtered using 220µF filter capacitors.

Remote control circuit

Now let's take a look at the Remote Control circuitry which is also shown on Fig.1.

Signals from the remote are picked up by infrared receiver IRD1 and the resulting data fed to RB0 (pin 6) of a PIC16F88-I/P microcontroller (IC3). IC3 then decodes this data and, depending on the button pressed on the remote, either drives the volume control motor (via an external transistor circuit) or sends its RB6, RB7 or RB5 output low to select a new input.

Fig.2 shows IRD1's internal details. It has just three leads but is a complete infrared detector and processor.



SC STEREO PREAMPLIFIER & REMOTE VOLUME CONTROL

Fig.1: each channel of the preamp stage (top) is based on a low-distortion LM833N dual op amp (left channel only shown). IC1a has a gain of two while IC1b functions as a unity gain buffer to provide a constant low-impedance output. The remote volume control section (immediately above) is based on a PIC16F88-I/P microcontroller (IC3). This processes the signal from infrared detector IRD1 and controls a motorised pot via H-bridge transistors Q1-Q4.

Parts List

Preamp & Remote Volume Control Module

1 PCB, code 01111111, 201 x 63mm
1 Alpha dual-ganged 20kΩ log motorised pot (VR1) (Altronics Cat. R2000)
1 1kΩ horizontal trimpot (VR2)
1 10-pin PC-mount IDC header socket (Altronics P5010)
1 18-pin DIP nachined IC socket
2 8-pin DIP machined IC sockets
2 vertical PC-mount RCA sockets, white (Altronics P0131)
2 vertical PC-mount RCA sockets, red (Altronics P0132)
1 3-way PC-mount screw terminal block, 5.08mm pitch (Altronics P2035A – do not substitute)
1 4MHz crystal (X1)
4 ferrite beads (Altronics L5250A)
1 3-way SIL pin header
1 2-way SIL pin header
1 jumper links to suit header
1 6.35mm chassis or PCB-mount single-ended spade connector (eg, Altronics H2094)
2 100mm cable ties
4 M3 x 25mm tapped metal spacers
4 M3 x 6mm screws
1 M4 x 10mm screw
1 M4 nut
1 M4 flat washer
1 M4 star washer
250mm 0.8mm tinned copper wire
180mm light-duty red hook-up wire
180mm light-duty black hook-up wire

Semiconductors

2 LM833 op amps (IC1, IC2)
1 PIC16F88-I/P programmed with "0111111A.hex" (IC3)
1 infrared receiver module (IRD1) (Altronics Z1611A, Jaycar ZD1952)
1 7805 5V regulator (REG3)
2 BC327 PNP transistors (Q1,Q3)
2 BC337 NPN transistors (Q2,Q4)
1 3mm blue LED (LED1)
1 3mm orange LED (LED2)
1 3mm yellow LED (LED3)

Capacitors

2 220µF 25V PC electrolytic
1 100µF 25V PC electrolytic
2 100µF 16V PC electrolytic
6 22µF NP electrolytic
1 10µF 16V PC electrolytic
2 4.7µF NP electrolytic
6 100nF MKT polyester
1 10nF MKT polyester
4 470pF MKT polyester or MKP polypropylene (do not use ceramic)
2 22pF ceramic

Resistors (0.25W, 1%)

4 100kΩ	4 2.2kΩ
2 22kΩ	4 1kΩ
1 18kΩ	2 330Ω
1 10kΩ	7 100Ω
2 4.7kΩ	1 22Ω
1 2.7kΩ	1 10Ω

Input Switching Module

1 PCB, code 01111112, 109.5 x 94.5mm
3 DPDT 5V relays, PC-mount (Altronics S4147)
3 PC-mount gold-plated dual RCA sockets (Altronics P0212)
4 M3 x 10mm tapped spacers
1 10-pin PC-mount IDC header socket (Altronics P5010)
1 14-pin PC-mount IDC header socket (Altronics P5014)
1 8-pin DIP machined IC socket
1 vertical PC-mount RCA socket, white (Altronics P0131)
1 vertical PC-mount RCA socket, red (Altronics P0132)
2 ferrite beads (Altronics L5250A, Jaycar LF1250)
4 M3 x 6mm machine screws

Semiconductors

1 LM393 comparator (IC4)
3 BC327 PNP transistors (Q5-Q7)
1 BC337 NPN transistor (Q8)
3 1N4004 diodes (D1-D3)

Capacitors

2 10µF 16V electrolytic
2 100nF MKT polyester
2 470pF MKT polyester or MKP polypropylene (do not use ceramic)

Resistors

3 100kΩ	11 2.2kΩ
2 10kΩ	6 100Ω

Switch Module

1 PCB, code 01111113, 66 x 24.5mm
1 14-pin PC-mount IDC header socket (Altronics P5014)
3 PC-mount pushbutton switches with blue LEDs (Altronics S1173, Jaycar SP0622)

Test Cables

2 14-pin IDC line sockets
2 10-pin line sockets
1 350mm length 14-way IDC cable
1 250mm length 10-way IDC cable

Note: 470pF MKP or MKT capacitors are available from Element14 (1413947 or 1005988) and from Rockby Electronics (35065 or 34463).

It picks up the 38kHz infrared pulse signal from the remote and amplifies this to a constant level. This is then fed to a 38kHz bandpass filter and then demodulated to produce a serial data burst at IRD1's pin 1 output.

IC1 decodes the signals from IRD1 according to the RC5 code sent by the remote (RC5 is a Philips remote control protocol). There are three different remote control "modes" (or devices) to choose from – either TV, SAT1 or SAT2 – and you must also program the remote with the correct code (see panel next month). The default mode is TV but SAT1 can be selected by pressing button S1 (on the Switch Board) during power up, while SAT2 can be selected by pressing S2 during power up. Pressing S3 at power up reverts to TV mode.

Motor drive

IC1's RB1-RB4 outputs drive the bases of transistors Q1-Q4 via 1kΩ resistors. These transistors are arranged in an H-bridge configuration and control the motor.

The motor is off when RB1-RB4 are all high. In that state, RB3 & RB4 turn PNP transistors Q1 & Q3 off, while RB1 & RB2 turn NPN transistors Q2 & Q4 on. As a result, both terminals of the motor are pulled low and so the motor is off. Note that the emitters of Q2 & Q4 both connect to ground via

a common 10Ω resistor (more on this shortly).

The transistors operate in pairs so that the motor can be driven in either direction (to increase or decrease the volume). To drive the motor clockwise, RB2 goes low and turns off transistor Q2, while RB3 goes low and turns on Q1. When that happens, the lefthand terminal of the motor is pulled to +5V via Q1, while the righthand terminal is pulled low via Q4. As a result, current flows through Q1, through the motor and then via Q4 and the 10Ω resistor to ground.

Conversely, to turn the motor in the other direction, Q1 & Q4 are switched off and Q2 & Q3 are switched on (RB2 & RB4 high). As a result, the righthand motor terminal is now pulled to +5V via Q3, while the lefthand terminal is pulled low via Q2.

The voltage across the motor depends on the voltage across the common 10Ω emitter resistor and that in turn depends on the current. Typically, the motor draws about 40mA when driving the potentiometer but this rises to over 50mA when the clutch is slipping. As a result, the motor voltage is around 4.5-4.6V due to the 0.4-0.5V drop across the 10Ω resistor (the rated motor voltage is 4.5V).

Current sensing & muting

Once the pot's wiper reaches its fully clockwise or anti-clockwise position, a clutch in the gearbox begins to slip. This prevents the motor from stalling and possibly overheating if the button on the remote continued to be held down. The clutch mechanism also allows the user to manually rotate the pot shaft if necessary.

The muting function operates by using the microcontroller to detect when the wiper reaches its anti-clockwise limit. It does this by indirectly detecting the increase in the motor current when the limit is reached and that's done by sampling the voltage across the 10Ω resistor using trimpot VR2.

The sampled voltage at VR2's wiper is filtered using an 18kΩ resistor and a 100nF capacitor (to remove the commutator hash from the motor) and applied to IC3's analog AN3 input (pin 2). IC3 then measures the voltage on AN3 to a resolution of 10-bits, or about 5mV. Provided this input is below 200mV, the PIC microcontroller allows the motor to run. However, as soon as the voltage rises above this 200mV limit,

How We Tweaked The Preamplifier

As stated in the article, the circuit and PCB for the preamplifier/remote volume control are based directly on the preamplifier designed for the Class-A Stereo Amplifier and published in August 2007. While we were adding the input switching functions, we sought to improve the performance at the same time. The changes were as follows:

(1) The 4.7µF non-polarised capacitors at the input of each channel were increased to 22µF. This slightly (but measurably) reduces harmonic distortion, especially at low frequencies, and also slightly reduces noise.

The reason for this is that the non-linearities of electrolytic capacitors become significant as the signal frequency is reduced and their resulting impedance rises to become comparable with the surrounding circuit impedances. By using larger values, we reduce the capacitors' impedance and therefore their distortion contribution. The noise reduction at low frequencies is also due to the larger capacitor's lower impedance, which is part of the source impedance for the non-inverting inputs of IC1a & IC2a (pin 3).

We also increased the 1µF non-polarised capacitors at the wipers of the potentiometer to 4.7µF for the same reason. This results in a further measurable reduction in THD+N (total harmonic distortion and noise).

(2) The feedback resistors for IC1a & IC2a have been reduced from 4.7kΩ to 2.2kΩ. At the same time, the feedback capacitor has been increased to 470pF to keep the frequency response the same. As before, this is done to lower the source impedance seen by op amps IC1a & IC2a, this time for the inverting input (pin 2).

Lower value resistors also produce less Johnson-Nyquist (thermal) voltage noise. The resulting improvement is again small but measurable.

(3) The four ceramic capacitors have been changed to plastic-film types, either MKT polyester or MKP polypropylene. These includes the aforementioned 470pF feedback capacitors as well as the two RF filter capacitors, which were 560pF but have been changed to the more common value of 470pF.

MKT polyester or MKP polypropylene types have now been specified because regular ceramic capacitors exhibit significant non-linearity. NP0/C0G ceramic capacitors have better linearity than the more common types (X7R, Y5V, etc) but are still not quite as good as metallised dielectric capacitors (eg, MKP, MKT).

This change is responsible for a large reduction in distortion above 1kHz – see Fig.12. For the same reason, we are also specifying metal-film types for the RF filter capacitors on the new Input Selector board. The final result is a THD+N which is virtually flat with frequency (see Fig.12).

(4) LM833 dual low-noise op amps are now specified instead of the newer LM4562 types used previously. While the LM4562 is better on paper, the Audio Precision System One generally reports lower distortion when we substitute an LM833 or NE5532 (the LM833 has slightly lower noise).

In this particular case, the LM833 gives about a 6dB improvement in the signal-to-noise ratio, even though its noise voltage is supposedly higher. We have some theories to explain this but they're quite involved and we don't have room to go into them here. Since the LM833 is easier to get, substantially cheaper and performs better in this circuit, it's the obvious choice.

(5) We have added 4.7kΩ resistors between the pot wipers and ground. This has two benefits. First, it effectively lowers the source impedance seen by the following op amp stage in each channel, lowering the noise floor. And second, it also lowers the high-frequency distortion by reducing the coupling between tracks, due to the lower impedance signal path (we're starting to sound like a broken record but low impedance really is critical).

This results in a fairly substantial improvement in the THD+N performance when the volume control is at an intermediate setting and the improvement is greatest at its -6dB setting (see Fig.11). This does cause a slight deviation from the log-law of the pot. Having said that, most log pots only have an approximate logarithmic relationship anyway.

The effect of a shunt resistor on a theoretical pot with an ideal log law is shown in Fig.10. The most noticeable difference in volume control progressiveness is that it doesn't increase as rapidly as the pot is advanced but then increases more rapidly towards the end. In practice, with a motorised volume control being used, the effect will not be noticeable.

Of course, we would be better off using a lower value pot (say 4.7kΩ) but a 20kΩ log motorised pot is all that's readily available for now. If a 4.7kΩ log motorised pot does become available, it can be directly substituted and the 4.7kΩ shunt resistors left out.

Nicholas Vinen

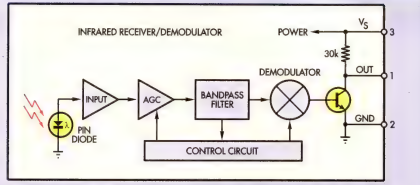


Fig.2: the IR receiver contains a lot more than just a photodiode. Also included are an amplifier plus AGC, bandpass filtering and demodulation circuits, all in the 3-pin package. After the 38kHz carrier is removed, the data appears on pin 1, ready to be processed by the microcontroller.

the motor is stopped.

When the motor is running normally, the current through it is about 40mA, which produces 0.4V across the 10Ω resistor. VR2 attenuates this voltage and is adjusted so that the voltage at AN3 is slightly below the 200mV limit.

When the pot reaches its end stop, the extra load imposed by the slipping clutch increases the current and so the voltage applied to AN3 suddenly rises above 200mV. This is detected by IC3 during muting and it then switches the H-bridge transistors (Q1-Q4) to immediately stop the motor.

Note that AN3 is monitored only during the muting operation (ie, when the Mute button on the remote is pressed). At other times, when the volume is being set by the Up or Down buttons on the remote, the voltage at AN3 is not monitored. As a result, the clutch in the motor's gearbox assembly simply slips when the potentiometer reaches its clockwise or anticlockwise limits.

Pressing the Mute button on the remote again after muting returns the volume control to its original setting. This "mute return" feature is enabled by installing link LK3 to pull RA4 (pin 3) to +5V. Conversely, removing LK3 and installing LK4 to pull RA4 to ground disables mute return.

Indicator LEDs

LEDs 1-3 indicate the status of the circuit. The blue Power LED (LED1) lights whenever power is applied to the circuit.

The other two LEDs – Ack (acknowledge) and Mute – light when their respective RA2 and RA1 outputs are pulled high (ie, to +5V). As indicated previously, the Ack LED (orange) flashes whenever RB0 receives an infrared signal from the remote, while the Mute LED (yellow) flashes during the Mute operation and then stays lit while the volume remains muted.

Input selector control

Ports RB6, RB7 & RB5 of IC3 control the relays on the Input Selector Board. These ports go low when their corresponding 1, 2 & 3 buttons on the remote are pressed and are open-circuit (O/C) at other times.

As shown, RB6, RB7 & RB5 are connected to pins 1-6 of 10-way header socket CON7 (each output is connected to two pins in parallel). In addition, pins 7 & 8 of CON7 are connected to the +5V rail, while pins 9 & 10 go to ground.

As previously indicated, CON7 is connected to a matching header socket on the Input Selector Board via an IDC cable. This provides both the input selection signals and the supply rails to power this module.

Crystal oscillator

Pins 15 & 16 of IC3 are the oscillator pins for 4MHz crystal X1 which is used to provide the clock signal. This oscillator runs when the circuit is first powered up for about 1.5 seconds. It also runs when ever an infrared signal is received at RB0 or when a button on the switch board is pressed and then for a further 1.5 seconds after the signal ceases. The oscillator then shuts down and the processor goes into sleep mode.

This ensures that no noise is radiated into the sensitive audio circuitry when the remote control circuit is not being used (ie, if the volume is not being altered or input selection is not taking place).

Note that shut-down does not occur if a Muting operation is still in process.

In addition, the motor is enclosed by a metal shield which reduces radiated electrical hash from the commutator brushes. A 10nF capacitor connected directly across the motor terminals also prevents commutator hash from being transmitted along the supply leads, while further filtering is provided by a 100nF capacitor located at the motor output terminals on the PCB.

Power for the remote control circuit is derived from the +15V supply to the preamplifier. This is fed via a 22Ω resistor to regulator REG3 to derive a +5V supply rail to power IC3, IRD1 and the H-bridge driver stage for the motor.

A 100µF capacitor filters the input to REG3, while 10µF and 100nF capacitors decouple the output. In addition, the supply to IRD1 is filtered using a 100Ω resistor and a 100µF capacitor to prevent it from false triggering due to "hash" on the 5V rail.

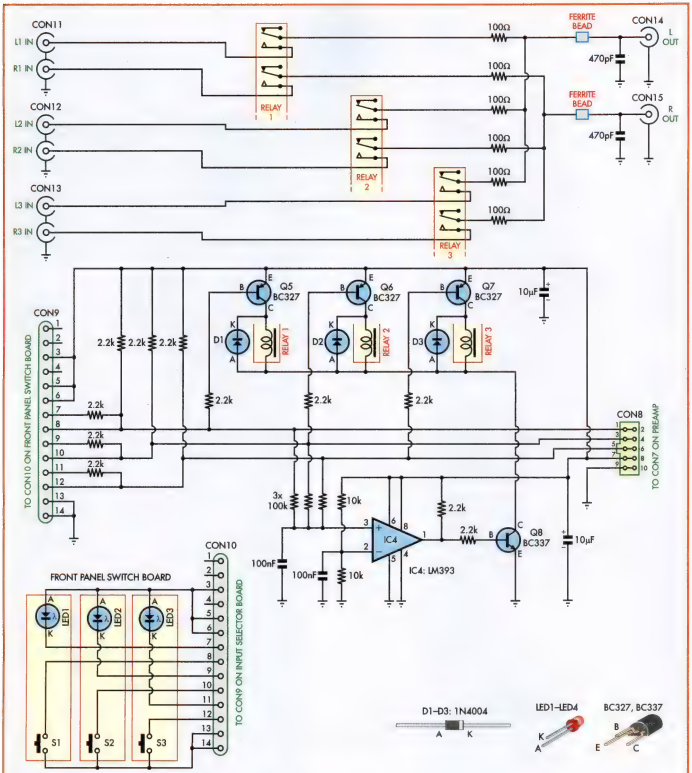
Input Selector circuit

The Input Selector circuit (see Fig.3) uses three 5V DPDT relays (RLY1-RLY3) to select one of three stereo inputs: Input 1, Input 2 or Input 3. The relays are controlled by PNP transistors Q5-Q7, depending on the signals from the PIC16F88-I/P microcontroller in the Remote Control circuit (and fed through from CON7 to CON8).

As shown, the incoming stereo line-level inputs are connected to the NO (normally open) contacts of each relay. When a relay turns on, its common (C) contacts connect to its NO contacts and the stereo signals are fed through to the left and right outputs via 100Ω resistors and ferrite beads. The resistors isolate the outputs from the audio cable capacitance, while the beads and their associated 470pF capacitors filter any RF signals that may be present.

When button 1 is pressed on the remote, pins 1 & 2 on CON8 are pulled low (via RB6 of IC3 in the Remote Control circuit). This pulls the base of transistor Q5 low via a 2.2kΩ resistor and so Q5 turns on and switches on RLY1 to select Input 1 (CON11). Similarly, RLY2 & RLY3 are switched on via Q6 & Q7 respectively when buttons 2 and 3 are pressed on the remote.

Only one relay can be on at any



SC 2011 ULTRA-LD AMPLIFIER INPUT SELECTOR

Fig.3: the Input Selector circuit uses relays RLY1-RLY3 to select one of three stereo inputs: Input 1, Input 2 or Input 3. These relays are switched by transistors Q5-Q7, depending on the signals from the PIC16F88-I/P microcontroller on the preamp board. Alternatively, switches S1-S3 on the switch board can also be used to select the inputs.

time. Pressing an input button (either on the remote or the switch board) turns the currently-activated relay off before the newly-selected relay turns on. If the input button corresponds to the currently-selected input, then no changes takes place. The last input selected is restored at power up.

Also shown on Fig.4 is the circuitry for the front panel Switch Board. This consists of three momentary contact pushbuttons with integral blue LEDs

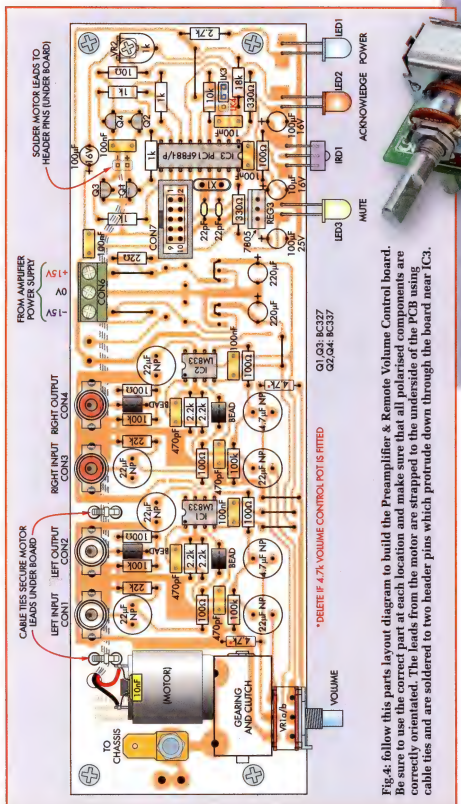


Fig.4: follow this parts layout diagram to build the Preamplifier & Remote Volume Control board. Be sure to use the correct part at each location and make sure that all polarised components are correctly orientated. The leads from the motor are strapped to the underside of the PCB using cable ties and are soldered to two header pins which protrude down through the board near IC3.

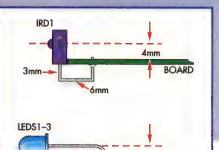


Fig.5: bend the leads for IRD1 and the three LEDs as shown here before installing them on the preamp PCB. The centre line of each lens must be 4mm above the board surface.

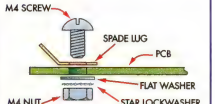


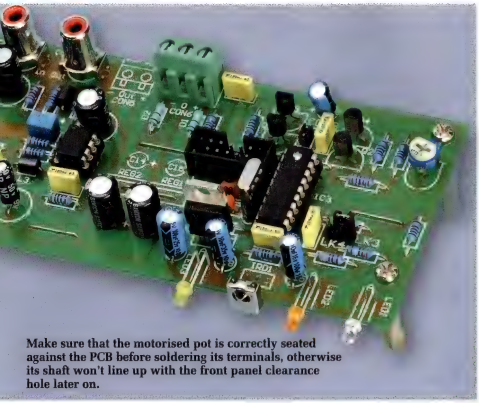
Fig.6: the spade connector lug is mounted on the PCB as shown here. Alternatively, the board can accept a solder-type connector.

(LEDs1-3) plus a 14-way header socket (CON10) which is connected to CON9 via an IDC cable.

One side of each switch is connected to ground, while the tops of S1-S3 are respectively connected back to the RB6, RB7 & RB5 ports of IC3 in the Remote Control circuit. When a switch is pressed, it pulls its corresponding port low and this wakes the microcontroller up which then turns on the corresponding relay and promptly goes back to sleep again (ie, the port remains low).

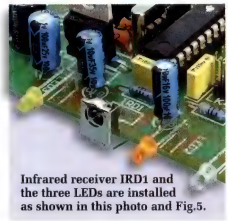
The anodes of LEDs1-3 are connected to +5V, while their cathodes are respectively connected to the RB6, RB7 & RB5 ports via 2.2kΩ current limiting resistors. As a result, when one of these ports switches low to select a new input, it lights the corresponding switch LED as well. This occurs whether the input was selected using the remote control or pressing a switch button.

At the same time, the cathodes of the other LEDs are held high via 2.2kΩ



Make sure that the motorised pot is correctly seated against the PCB before soldering its terminals, otherwise its shaft won't line up with the front panel clearance hole later on.

This view shows how the leads and the 10nF capacitor are connected to the pot motor terminals.



Infrared receiver IRD1 and the three LEDs are installed as shown in this photo and Fig.5.

pull-up resistors to the +5V rail and are off.

Preventing switch conflicts

IC4 and Q8 prevent more than one relay from turning on if two or more input switches – either on the remote or the switch board – are pressed simultaneously. This circuit also ensures that the currently-activated relay is switched off if a different input button is pressed (ie, before the newly-selected relay is turned on).

IC4 is an LM393 comparator and is wired so that its non-inverting input (pin 3) monitors the three switch lines via 100kΩ resistors. These resistors function as a simple DAC (digital-to-analog converter). If one switch line is low, the voltage on pin 3 of IC1 is 3.3V; if two are low (eg, if two switches are pressed simultaneously), pin 3 is at 1.67V; and if all three lines are low, pin 3 is at 0V.

This pin 3 voltage is compared to a 2.5V reference on IC1's inverting input (pin 2). Its pin 1 output is high only when one switch line is low and this turns on Q8 which switches the bottom of the relay coils to ground. This allows the selected relay to turn on.

However, if two or more switch lines are low, IC4's output will be low and so Q8 and all the relays turn off. Similarly, if one switch line is already low and another input is selected (pulling its line low), IC4's output will briefly go low to switch off all the relays before going high again (ie, when the micro toggles its RB5-RB7 outputs) to allow the new relay to turn on.

IC4's 2.5V reference is derived from a voltage divider consisting of two 10kΩ resistors connected across the 5V supply rail.

Construction

Fig.4 shows the assembly details for the Preamplifier & Remote Volume Control module (the 3-Input Selector module and the Switch Board assemblies will be described next month).

All the parts for the preamplifier are installed on a PCB coded 01111111 and measuring 201 x 63mm. The external connections to the power supply are run via insulated screw terminal blocks while the audio signals are fed in via vertical RCA sockets.

Begin by checking that the motorised pot and the various connectors fit correctly. That done, start the assembly by installing the 10 wire links. You can straighten the link wire by securing one end in a vice and then pulling on the other end using a pair of pliers, to stretch it slightly.

Note that four of the links are used to replace several parts that were necessary for the Class-A Amplifier, ie, diodes D1 & D2 and regulators REG1 & REG2. These parts are still shown on the screened overlay on the PCB but are not installed if you are powering the board using the Ultra-LD Mk.3 Power Supply board (since that board supplies the necessary regulated ±15V supply rails).

In addition, the two 220µF electrolytic capacitors previously installed across the regulator inputs are omitted, while the 100µF capacitors on the output side are now 220µF.

It's just a matter of ignoring the screened overlay and installing the parts and the links exactly as shown in Fig.4. Note the different arrangements used to link out REG1 & REG2. REG1 is bypassed by linking its two outside pads while REG2 is bypassed by linking its middle and righthand pads.

The resistors can go in next (use your DMM to check the values), followed by the four ferrite beads. Each bead is installed by feeding some 0.7mm tinned copper wire through it and then bending the leads down through 90° on either side to fit through their holes in the PCB. Push each bead all the way

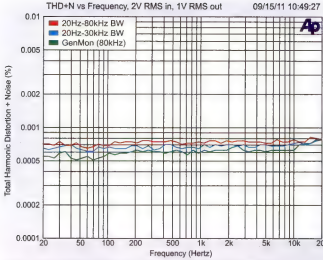


Fig.7: the THD+N for bandwidths of 20Hz-80kHz and 20Hz-30kHz and a gain of 0.5. It's typically 0.0007% or less for a 20Hz-30kHz bandwidth.

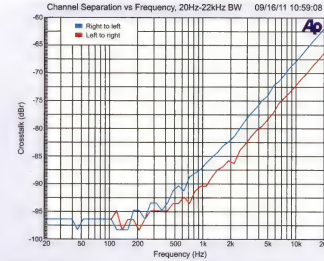


Fig.8: the channel separation vs frequency. It's typically better than 87dB up to 1kHz and is still around 70dB or better at 10kHz.

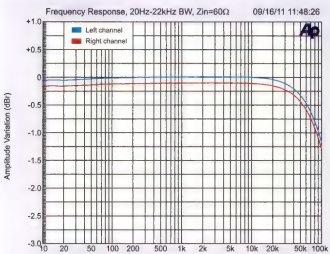


Fig.9: the frequency response is virtually ruler flat from 10Hz to 20kHz and then rolls off gently above that to be about -1.25dB down at about 100kHz.

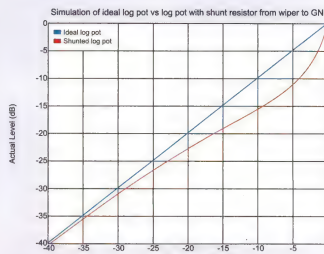


Fig.10: this graph shows the simulated response curve of a 20kΩ pot with a 4.7kΩ shunt resistor from wiper to ground (red) compared to an ideal log pot (blue).

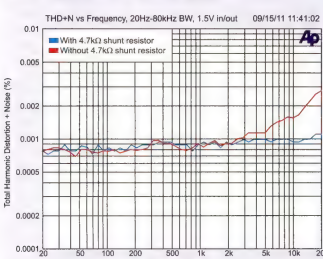


Fig.11: the effect on THD+N with and without the 4.7kΩ shunt resistor across the pot. The shunt resistor gives a worthwile reduction above about 3kHz.

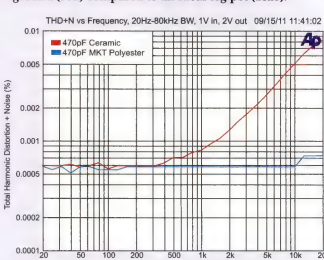


Fig.12: using a 470pF MKT polyester feedback capacitor instead of a ceramic type also gives a big reduction in THD+N at the high-frequency end.

Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
4	100kΩ	brown black yellow brown	brown black black orange brown
2	22kΩ	red red orange brown	red red black red brown
1	18kΩ	brown grey orange brown	brown grey black red brown
1	10kΩ	brown black orange brown	brown black black red brown
2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
1	2.7kΩ	red violet red brown	red violet black brown brown
4	2.2kΩ	red red red brown	red red black brown brown
4	1kΩ	brown black red brown	brown black black brown brown
2	330Ω	orange orange brown brown	orange orange black black brown
7	100Ω	brown black brown brown	brown black black black brown
1	22Ω	red red black brown	red red black gold brown
1	10Ω	brown black black brown	brown black black gold brown

down so that it sits flush against the PCB before soldering its leads.

That done, install machined-pin DIL sockets for the three ICs. Make sure that each socket is seated flush against the PCB and that it is orientated correctly (IC3 faces in the opposite direction to ICs 1 & 2). It's best to solder two diagonally opposite pins of a socket first and then check that it sits flush with the board before soldering the remaining pins.

The MKT and ceramic capacitors can now go in, followed by the non-polarised capacitors and the polarised electrolytics. Note that the 100µF capacitor to the left of LED3 must be rated at 25V.

Be sure to use MKT (or polypropylene) capacitors for the 470pF feedback capacitors in the preamplifier (ie, between pins 1 & 2 of IC1a & IC2a). Using ceramic capacitors in these positions will degrade the distortion performance (see panel). The same goes for the 470pF RF bypass capacitors at the inputs of IC1a & IC2a. Once again, be sure to use MKT types.

The next step is to install the four transistors (Q1-Q4) in the remote control section. Be sure to use the correct type at each location. Q1 & Q3 and both BC327s, while Q2 & Q4 are BC337s. It will be necessary to crank their leads with a pair of needle-nose pliers, so that they fit down onto the board properly.

The 3-way DIL (dual-in-line) pin header for LK3 & LK4 can now be installed, followed by a 2-way pin header to terminate the motor leads (just to the right of Q1 & Q3). To install the 2-pin header, first push its pins down so that their ends are flush with the top of the plastic, then install the header from the component side and solder the pins underneath.

This will give about 7mm pin lengths on the track side of the PCB to terminate the leads from the motor. As shown in Fig.4, these leads are run underneath the PCB.

Crystal X1, trimpot VR2, the 3-way screw terminal block (CON6) and the four vertical RCA sockets (CON1-CON4) can now all be installed. Use white RCA sockets for the left channel input and output positions and red for the right channel positions.

Mounting the motorised pot

It's absolutely critical to seat the motorised pot (VR1) correctly against the PCB before soldering its leads, If this is not done, it won't line up correctly with its clearance hole in the amplifier's front panel later on.

In particular, note that the two lugs at the rear of the gearbox cover go through slotted holes in the PCB. Use a small jeweller's file to enlarge these if necessary.

Once the pot fits correctly, solder two diagonally opposite pot terminals and check that everything is correct before soldering the rest. The two gearbox cover lugs can then be soldered.

That done, connect the motor terminals to the 2-pin header using light-duty hook-up cable. These leads are twisted together and pass through a hole in the board immediately behind the motor. They are then secured to the underside of the PCB using cable ties and soldered to the header pins.

Be sure to connect the motor's positive terminal to the positive header pin. Once the cable is in place, solder the 10nF capacitor directly across the motor terminals.

Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
470pF	NA	470p	471
22pF	NA	22p	22

Mounting the LEDs

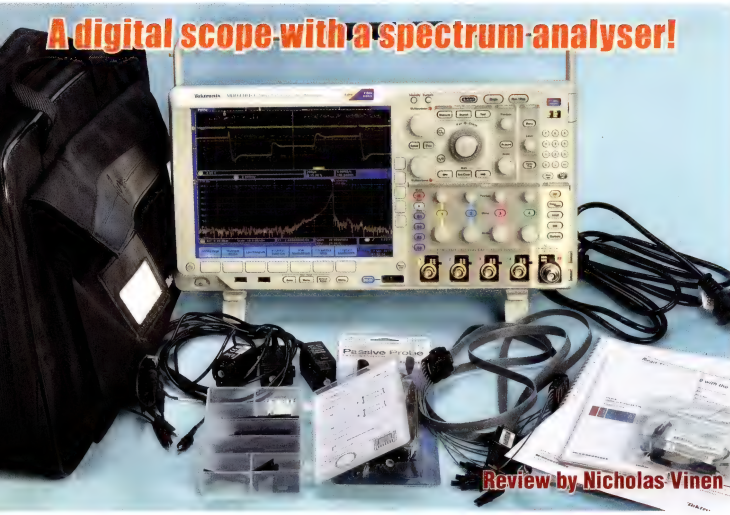
Fig.5 shows how infrared receiver IRD1 and the LEDs are mounted. Note that the details shown for IRD1 are for the Altronics Z1611A device. **The Jaycar ZD1952 is slightly different – just be sure to install it with its lens 4mm above the PCB.**

It's a good idea to cut 3mm-wide and 6mm-wide templates from thick cardboard and bend IRD's leads around these. Similarly, for the LEDs, you will need 10mm-wide and 4mm-wide templates. The 4mm template is used as a spacer when mounting the LEDs.

The assembly can now be completed by installing the spade connector to the left of the motorised pot. This connector can either be a vertically-mounted solder type or a screw-mounted type. If you have the latter, it's secured using an M4 screw, a flat washer, a shakeproof washer and a nut (see Fig.6).

Leave the three ICs out of their sockets for now. They are installed later, after the power supply checks have been completed.

Next month, we'll describe the Input Selector module and Switch Board assemblies and detail the test procedure. We'll also describe how the remote control is set up. SC



Tektronix MDO4104-3 Mixed Domain Oscilloscope

This first-of-its-kind product combines a mixed signal oscilloscope (with four analog and 16 digital channels) and a 3 or 6GHz spectrum analyser (with an impressive capture bandwidth, over 1GHz). But it's far more than just three instruments in one package.

Tektronix must think that they've come up with a new type of test instrument since they've invented a name for it: "mixed domain oscilloscope". We reckon they're probably right. Digital storage oscilloscopes (DSOs) and spectrum analysers have both been around for yonks but while they're individually useful, this unit can do some things that they can't do by themselves.

So what do they mean by "mixed domain"? It may help to think back to high-school mathematics. If you weren't too busy making paper planes or programming games into your graphing calculator, you may remember that when a function is plotted on a graph, the x-axis is called the "domain" and the y-axis the "range".

For the classic oscilloscope display, the x-axis is time and the y-axis is voltage (or current). Hence these scopes operate within the "time domain". Similarly, a spectrum analyser plots frequency on the x-axis and power on the y-axis. So we can say that a spectrum analyser operates with a "frequency domain".

So a mixed domain oscilloscope can display data in

either or both forms. We should point out that you can view the same signal either way, eg, as a plot of voltage-versus-time or power-versus-frequency. Each view is useful for different purposes; a spectrum is invaluable for analysing a radio frequency (RF) signal but is not so useful for debugging a serial bus!

It would have been tempting for Tektronix to just shoehorn two instruments into one box and call it something new. That is definitely not what they have done though. Clearly, a lot of effort has gone into integrating the two and the result is a device which allows you to capture and analyse data in ways that were not possible before.

The power of mixed domains

A digital spectrum analyser typically samples the signal at a high rate for some period (say 1ms), then converts the captured data to the frequency domain using a mathematical transform (eg, a fast Fourier transform or FFT). The display then shows the signal frequencies present during the capture period. For better frequency resolution ("resolution bandwidth"), a longer sampling period is necessary, to acquire more data for analysis.

If data is captured over a longer period than merely necessary for the analysis, it is possible to "slide the window" (ie, the portion of data being analysed) within this period. This results in a series of spectrum plots, showing how the frequencies present in the signal shift over time. This can then be correlated with the time domain data captured by the oscilloscope portion of the instrument, so that the operation of the RF control circuitry can be observed simultaneously with the RF output.

By this point, you should be starting to get an idea of what this device is capable of.

In practice, the data for time and frequency domain analyses are stored separately. For the regular scope functions (ie, time domain), a generous 20Mpoints of storage is available. The spectrum analyser can capture an astounding one gigapoint (ie, one billion points). That corresponds to 2.5 milliseconds of signal when the spectrum analysis window has maximum span (>2GHz) and longer for smaller spans, to a maximum of 79ms (span of <125MHz).

As well as allowing for a large "sliding window", this also gives you a lot of capture bandwidth. This is the difference between the lowest and highest frequencies which can be displayed simultaneously. So you can, for example, monitor the RF output of a circuit at 900MHz and 2.4GHz simultaneously (see Fig.1) or even 2.4GHz and 5.6GHz (with the 6GHz model). Since many digital wireless devices can operate on multiple frequencies, this can be handy.

A demonstration

The Tektronix demo board provides a number of examples to demonstrates the MDO's utility. One of the most interesting is the frequency hopping demo, shown in Fig.2. The screen is split, with the time domain display at the top and frequency domain at the bottom. The horizontal orange bar shows which portion of the time domain display corresponds to the spectrum analysis below.

For this demo we have "frozen time" by pressing the run/stop button so what is shown in Figs.2-4 is based only on data stored in the scope's memory.

The frequency analysis time span (ie, the width of the orange bar) depends on the current resolution bandwidth.

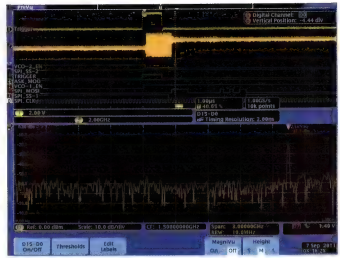


Fig.1: both analog and digital channels are enabled here, as well as the spectrum display. You can see the serial commands between the controller IC and the voltage controlled oscillator (VCO). This also demonstrates the incredible capture bandwidth available as we can observe the output shifting from 900MHz to 2.4GHz without having to re-sample the data (orange trace shows frequency).

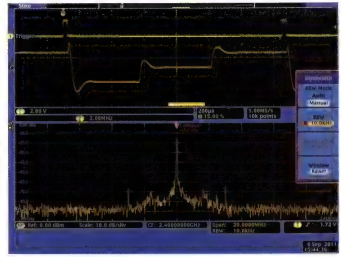


Fig.2: the MDO4104 operating in mixed domain mode, with scope traces at the top and the RF spectrum underneath. The RF signal is "frequency hopping" and the orange trace in the time domain display, at top, shows the changing centre frequency with time.

If the frequency resolution is made finer, for better peak discrimination, the orange bar necessarily gets wider and vice versa. There are limits to how far the orange bar can be moved, which is based on the RF capture timespan and this is determined by the frequency span.

Here we have a short enough timebase on the upper display that we can show a spectrum analysis at any point in time that's visible on the upper portion of the screen.

At the top of the spectrum display is an automatically generated "marker". For those familiar with scopes but not spectrum analysers, a marker is a cursor which highlights a particular frequency. The automatic markers (if enabled) appear at the tallest peaks (ie, frequencies with the highest powers). This unit can show up to 11 markers at once, detected using adjustable thresholds.

The marker shows us that in this case, the RF signal

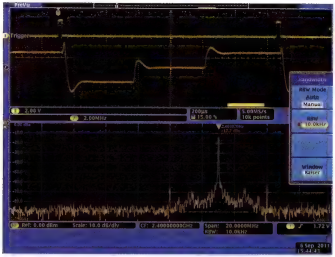


Fig.3: the same setup as Fig.1; all we did is change which portion of the captured data is being analysed for the spectrum display at bottom. Compare the position of the orange bar with Fig.1; at this later time, the RF signal has hopped to 2.403GHz (ie, up 30MHz) and so the peak has shifted. With this timebase (200µs), we can examine the spectrum at any point in time visible on the screen.

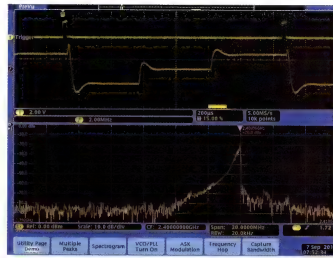


Fig.4: we are still analysing the same data captured for Fig.1 and Fig.2. This time the spectrum analyser frequency resolution has been changed from 10kHz to 20kHz and now we are observing the spectrum as the RF centre frequency is shifting. The lower frequency resolution allows us to analyse a smaller time period, to better observe the effects of the "hop", such as the overshoot.

peaks at exactly 2.4GHz during the selected timespan, with a power of -15.1dBm.

If more markers are shown, corresponding to lower peaks, their powers can be shown either as an absolute level or relative to the tallest peak. Markers can also be manually placed and the difference in frequency and power level between them read out.

In Fig.3 we have moved the spectrum analysis window forward in time, where the RF output has "hopped" up by 3MHz. As you can see, the orange trace in the time domain section is actually derived from the spectrum analysis and shows the frequency of the highest RF peak over time.

This immediately shows how the demo board's RF output tends to "overshoot" at each frequency hop, before settling down at the target frequency. A frequency analysis during the transition (Fig.4) shows the range of frequencies output during the "hop', as the oscillator frequency shifts. We changed the resolution bandwidth from 10kHz to 20kHz, allowing us to view the spectrum over a shorter period (compare the width of the orange bar with Fig.3).

As well as increasing the size of the window being analysed, finer frequency resolution settings also slow the spectrum display update.

There is one major restriction to this mixed domain mode; besides the scope running somewhat more slowly (depending on just how much number crunching it has to do), enabling the spectrum analysis also limits the offset between the trigger point and the start of the display. Be-

Specifications

Inputs	4 analog, 16 logic, 1 RF
Bandwidth (analog inputs)	500MHz@2.5GS/s or 1GHz@5GS/s (2.5GS/s for 3-4 channels)
Bandwidth (RF input)	50kHz-3GHz or 50kHz-6GHz
Analog memory depth	20Mpoints (10kpoints at maximum update rate)
Waveform update rate	Up to 50,000/s
Size & weight	229 x 439 x 147mm (5RU tall), 5kg
USB Ports	Four host ports, one device port
Other ports	Gigabit ethernet, VGA output, trigger out, frequency reference in

Spectrum Analyser

Capture bandwidth	>1GHz
Resolution bandwidth	20Hz-10MHz
Displayed Average Noise	-152dBm/Hz (5MHz-3GHz, typical); -143dBm/Hz (3GHz-6GHz, typical)
Residual Response	<-78dBm
Spurious Response	-60dBc typical, 2nd and 3rd harmonic
Maximum Input	+30dBm (1W) average continuous power
Acquisition Length	2.5ms (>2GHz Span) to 79ms (<125MHz span)

cause the spectrum analyser memory can only store data representing a limited time period, you can't go back any further than that (before the scope was triggered) or there just isn't any data to analyse.

With the spectrum display turned off though, you can go back hundreds of milliseconds before the trigger, to see the events leading up to it, depending on the memory depth and timebase selected. In the mixed domain mode, the maximum delay is generally in the range of 2.5-79ms, with the longer periods available with a smaller frequency span.

If you need to view earlier signals, the trigger settings must be changed. Normally this is not a problem since usually the RF phenomenon being investigated occurs after a particular digital or analog signal condition. But it's something the user must keep in mind.

User interface

As DSOs go, this one is particularly easy and pleasant to use. We especially like the dual general-purpose knobs. In situations where there are two or more settings to adjust, the two most-used settings are labelled "a" and "b", corresponding with those knobs. You can then adjust both without having to select between them using the "soft buttons" (which are along the right and bottom of the display).

Speaking of the screen, it is a 26cm (10.4-inch) 1024x768 TFT LCD and is particularly crisp, with good contrast.

Analog inputs

Let's take a closer look at time domain operation, ie, the scope functions. These are lifted from a Tektronix MSO4000-series DSO. In fact there are really only two differences; with three or four analog channels active, the sampling rate is 2.5 megasamples/second for the MDO4000-series compared to 5 megasamples/second for the MSO4000. Also the "aux input" BNC connector on the front panel has been removed to make room for the RF input.

We assume that the reduced sampling rate is due to the main processor's bandwidth being divided up between the four analog scope inputs and the RF input.

As mentioned earlier, both 500MHz and 1GHz bandwidth options are available for the analog channels. Four passive 500MHz/1GHz probes are provided. These have a low 3.9pF capacitance and a high 10MΩ input resistance. They come with a very good range of accessories, including spare tips, both hook and grabber tips, plenty of ground springs, ground clip, colour coding rings, IC lead probes and so on.

The analog inputs have low noise and with the supplied probes, give a sensitivity range from 10mV/div up to 100V/div. Each channel has its own vertical control (scale, offset knob and on/off/select button).

The amount of storage available is excellent at 20 megapoints. The zoom and pan functions work very well, allowing you to examine the overall waveform captured as well as the details. While the update rate is very good (50,000 updates per second), this is not available when using the full memory (20Mpoints). The maximum update rate is available with a memory depth of 10kpoints and is reduced when a larger memory is used (this is configurable in a number of steps).

One nice feature of the analog inputs is that they have two different bandwidth limiting options: 250MHz and

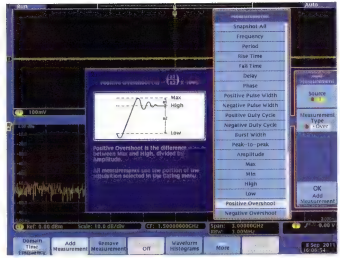


Fig.5: the measurement menu. Measurements can be shown for both time and frequency domain signals but the largest choice is for the time domain (ie, the traditional scope display). The detailed information for each measurement helps you understand exactly what is being measured.

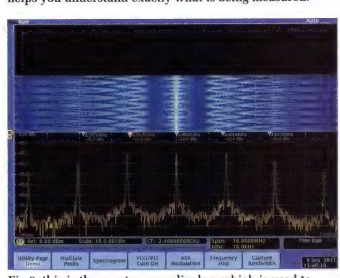


Fig.6: this is the spectrogram display, which is used to capture shifts in the frequency spectrum over time. The normal spectrum analysis is shown at bottom while the upper display changes to show amplitude as colour and constantly scrolls up, with the latest spectrum appearing at the bottom. Note how the peaks in the lower display (which were constantly shifting) correspond to the "hotter" colours above.

20MHz (in addition to 500MHz/1GHz, ie, no limiting). These are useful for eliminating noise and ringing when the signals being examined have a relatively low frequency.

There are five available sampling modes: normal, averaging (with a selectable number of averages), high resolution (very useful!), peak detect and envelope (min/max).

Logic analyser

All models come standard with a 16-channel logic analyser with an excellent time resolution of 60 picoseconds. Two logic heads are provided, which handle eight channels each.

The physical arrangement for the logic probes is especially nice. The ribbon cables are thin and flexible, the logic heads are small and the eight connectors on each

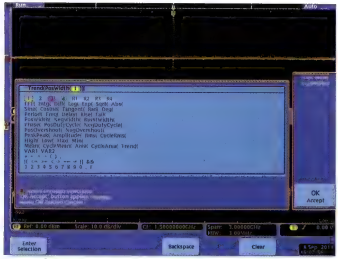


Fig.7: the range of operations available when building functions for the "advanced math" mode. We can think of a lot of useful things that you could do with such a powerful feature, such as displaying and calculating real power drawn from mains.

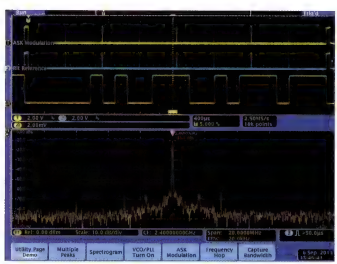


Fig.8: the amplitude shift keying (ASK) demo shows how the peak RF power can also be displayed in the time domain. This also shows how useful channel labels are. With 20 channels plus additional generated traces it's easy to get confused as to what each represents without the names shown.

head are colour coded. A ground wire can be connected for each head or separately for each pin; ground pins are provided which, if fitted, allow the wires to be plugged into standard 0.1-inch pitch, 2-way pin headers.

Also supplied are "probe tips" for plugging the wires into sockets/vias/test points and plenty of "IC grabbers". You also get a couple of little plastic blocks which allow the eight wires and ground for each logic head to be ganged together to form an 8x2 pin header socket, to suit male pin headers or PCB-mount IDC connectors.

There are eight serial decoding/triggering options available, at additional cost. These are: Embedded (I^2C/SPI), Audio (I^2S, left-justified, right-justified, TDM), Automotive (LIN/CAN), Extended Automotive (LIN/CAN/FlexRay), Computer (RS-23/422/485/UART), Ethernet (10BASE-T/100BASE-TX), USB (Low, Full and Hi-Speed) and Aerospace (MIL-STD-1553).

With these optional serial decoders, the triggering options become even more powerful. You can then trigger when a particular value appears on the bus and it's even possible to compare some bits in the serial packet and ignore others.

As well as displaying decoded data values in the trace display (up to four buses at a time), serial data can also be shown in a list format at the bottom of the screen. The search function(s) (described below) allow you to jump to a point in time where a particular value appears on a bus. In short, the logic analyser on this scope is very powerful and comprehensive.

Measurements

There are many measurements that can be applied to each channel. The menus are particularly nice, with a large graphical display showing what each one represents as you scroll through the list (see Fig.5). All analog and digital channels can be used for measurements although the list of available measurement modes for digital channels is smaller.

We like the fact that you can have as many measurements on screen as you want but unfortunately, they take up valuable screen real estate and so if you have lots active at once there's less room for traces.

Triggering

As you would expect, there are many trigger modes. As well as the usual ones, including the commonly-used Edge and Pulse Width triggering, there are also Timeout, Run, Setup & Hold and Rise/Fall Time which are all useful for debugging high-speed digital buses.

Then there is Video triggering which includes optional support for HDTV up to 1080p, as well as custom video triggering. We expect anybody working with video/TV these days would be involved with HDTVs and so would opt for this add-on.

One interesting trigger mode is "Logic" which is very powerful. You can select a mix of any of the analog or digital inputs and specify which combination of states is required to trigger the scope. One input can even be designated the "clock", which determines when the other channel states are sampled for triggering. You can also specify a minimum or maximum duration for this state to be held before the trigger occurs.

There is the usual setting for auto/normal triggering and when analog channels are used as a trigger input, there are other options: AC/DC coupling, high-frequency and low-frequency signal filtering, noise rejection and so on.

"Math" modes

The "math" mode of this scope is the best we've seen. As well as the usual modes (add, subtract, multiply, divide and FFT) there is also an "advanced math" mode which lets you enter a custom formula. This can include parameters representing the data from one or two analog channels. The function is computed over the time domain and the result displayed as a new trace.

A large array of operators are available for use in this mode, including integration and differentiation, trigonometric functions, logarithms and exponentials, absolute values, maximums, minimums and differences, periods frequencies, duty cycles . . . the list goes on (see Fig.7).

With the flexibility this feature provides, it has many uses. One example would be when measuring AC voltage and current using two analog channels – you could use the integration, multiplication and absolute value functions to display the instantaneous real power delivered to the load. You could probably also calculate and display the power factor in real time.

Other features

This scope has a search feature as standard. This allows you to quickly move along the time domain, jumping to particular points of interest, based on the search criteria. These locations can also be flagged with markers which is quite handy when using the zoom mode.

The search criteria are similar to the triggering modes, ie, markers can be placed at points based on edges, pulse widths, runts, setup & hold violations, specific logic bus data values and so on. You can then use the marker navigation buttons to skip between the matching events and examine them.

The search settings can be copied to the scope's trigger settings and vice versa. So once you have found a point of interest, you can easily set it up to trigger on that condition. The marker locations can also be saved to memory.

As well as the "live" traces, up to four reference traces can be enabled at once. Each shows a saved waveform.

There is also an optional limit/mask testing feature. Masks can be created from traces or can be taken from a USB drive. The live trace(s) are then compared against the mask and any violations flagged.

The scope also has an optional suite of "power applications". These are very useful for testing and diagnosing switchmode power supplies. With the correct probe set-up (voltage measured on channel 1 and current on channel 2), additional information is displayed: power quality, switching loss, switching harmonics, output ripple, control pulse modulation or transistor SOA (safe operating area) characteristics.

It can also display "histograms" above the traces, for a given channel. The scope gathers statistical data on the data captured from this channel and shows the distribution in the histogram, based on the spread of rising/falling edges (ie, jitter) or other aspects of the signal. The display includes readouts of the mean, standard deviation and other properties of the signal.

That's a lot of features in one unit. In fact there are even more that we could list but we don't really have the space. Let's just say it's feature-packed!

Spectrum analyser

Compared to the scope portion, the spectrum analyser is pretty easy to drive. There are five dedicated set-up buttons plus a numeric keypad for entering frequencies (which can also be altered with the two general purpose knobs). The five set-up buttons are labelled "RF", "Freq/Span", "Ampl", "BW" and "Markers".

As well as turning the spectrum analyser on and off, the "RF" button presents a menu where average/min/max readings can be turned on or off. The same menu also lets you enable and disable the RF traces in the time domain section (frequency, amplitude and/or phase), toggle the spectrogram mode (see Fig.7), configure automatic markers and change the RF trace labels, etc.

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The rear panel carries three USB ports (there are two more on the front panel), plus an ethernet socket, a video output socket and BNC connectors for a 10MHz reference (input) and an auxiliary output.

The "Freq/Span" button lets you select the displayed frequency range by setting either the centre frequency and span or the start and stop frequencies. "Ampl" controls the vertical axis, allowing you to select the display units, reference level and scale or turn automatic scaling on or off. The "BW" button sets the bandwidth resolution as either a ratio to the capture bandwidth or an absolute value in Hertz. The "Markers" button controls the automatic and manual markers, as mentioned earlier.

There are also controls to select which FFT window type is used for the frequency analysis: Kaiser, Rectangular, Hamming, Hanning, Blackman-Harris and Flat-Top.

Various measurements can be taken on the RF signal, including channel power, adjacent channel power ratio and occupied bandwidth. These are made through the same measurement interface as for the scope.

There is also an option available to add triggering based on RF power level to the unit (MDO4TRIG). If installed, the overall RF power level can be used as an input for the Pulse Width, Runt, Timeout, Logic and Sequence trigger modes.

Accessories

In addition to the analog and digital probes and associated accessories, the unit comes with a protective front panel cover, a BNC-connector to N-connector adaptor for the RF input (for signals <5GHz), a printed user manual, documentation and software CDs, calibration certificate and power cord.

The main unit has a VESA monitor mount on the back. This means that it can be attached to various stands, wall brackets, mounted in a rack, etc. It also has a Kensington lock for theft prevention.

Conclusion

The MDO4000-series is innovative and feature-packed. It will be an invaluable tool for engineers working with wireless communications.

This performance comes at a price, though; both monetary and in terms of some performance compromises. While the main processor in this unit is no doubt quite powerful, it has quite a lot of tasks to perform when all the features are running at once. It can get a bit bogged down if you try to do too much at once.

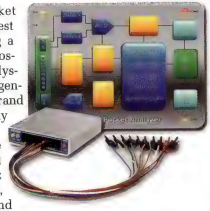
For that reason, it's best to keep the resolution bandwidth at a lower setting (ie, larger frequency step) initially and then increase the resolution once the signals you want to examine are on-screen.

The base model, MDO4054-X, with 500MHz analog inputs (2.5GS/s) and 3GHz spectrum analyser costs AUD $23,205+GST. The top-rated model (MDO4104-6) comes in at $33,180+GST. The price for the various options, including the serial decoding modules, varies but the latter are in the range of $1600-1800 each.

For more information or to purchase an MDO4000-series scope, contact TekMark Australia on 1300 811 355 or email **enquiries@tekmarkgroup.com** Or for New Zealand, call Nichecom Limited on +64-4-232-3233 or e-mail **Tektronix@nichecom.co.nz** SC

PRODUCT SHOWCASE

BitScope Pocket Analyser



The BitScope Pocket Analyser is a unique test instrument, combining a powerful mixed signal oscilloscope, protocol analyser, waveform and clock generator, spectrum analyser and data recorder in one tiny USB-powered device.

It offers 10 capture channels (2 analog and 8 digital) with 100MHz analog bandwidth, 40MSps logic speed and up to 12-bits analog resolution as well several output channels for its signal generators, triggers and external control signals.

The Pocket Analyser is fast, with a frame rate up to 100Hz driving a digital phosphor display. It works just like a quality stand-alone scope. View waveforms, plots, spectra and more on its smooth flowing real-time screen. Even live capture logic data can be viewed this way.

Alternatively large buffers support high speed one-shot capture with post-capture zoom, scrolling and measurement, or it can stream direct to disk for off-line replay and analysis.

Software is included for Windows, Mac OS X or Linux. Features include mixed signal, storage and sampling oscilloscopes, logic timing, SPI, CAN, I²C and UART packet decoders, a spectrum analyser, phase plotter and data recorder.

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Got a bunch of unknown diodes and zener diodes? Check 'em all with this . . .

Zener Diode Tester

This zener diode tester plugs into your digital multimeter and you can directly check any zener diode rated from 2.2V up to 100V. You can also check the forward voltage of diodes and test low-voltage Schottky diodes.

By JOHN CLARKE

WHILE MOST DIGITAL multimeters (DMMs) do include a diode test function, they do not test zener diodes. So how many zener diodes do you have stashed away which are not used because their value is unknown? In many cases, the type number will be missing or partially rubbed off or it is difficult to read because the print is so small. And even if it can be read, the type number will not directly give you the voltage rating. So unless you can look up the data for that type number, you are still "in the dark".

This Zener Tester is the answer. It plugs directly into your DMM, so that you can easily read the breakdown voltage of the zener being tested. The unit can measure all the common types, from very low values of around 2.2V right up to 100V. It's best for 400mW and 1W power devices, although it will also provide reasonably accurate measurements for 3W zener diodes.

The Zener Tester can also measure the breakdown voltage of other diode types such as tran-

sient voltage suppression (TVS) diodes, as well as standard and Schottky diodes with PIV (peak inverse voltage) ratings below 100V. That makes it suitable for testing many Schottky diodes that break down at 20, 30 or 40V depending on the type (eg, 1N5819 or 1N5822).

As with a standard diode tester, you can also measure the forward voltage, which is typically in the range of 0.2-0.8V.

How zener diodes work

Zener diodes are manufactured to provide a specified breakdown voltage where current will flow in the reverse direction. This is known as the "zener" voltage, after Clarence Zener who discovered the effect. The zener diode effect is the predominant operating mechanism for zener diodes with breakdown voltages up to 5.6V.

Above this voltage, the "avalanche" effect is more predominant. However, avalanche effect diodes continue to be called zener diodes regardless.

Zener diodes (breakdown below 5.6V) have a negative temperature coefficient and avalanche diodes (breakdown above 5.6V) have a positive temperature coefficient for their breakdown voltage. Zener diodes with a breakdown of around 5.6V have a zero temperature coefficient and so the breakdown voltage does not vary with temperature.

Fig.1 shows the typical zener characteristic. In the forward direction, the zener behaves as a diode and begins to conduct at about 0.7V. Conversely, in the reverse direction, there is very little current flow until the "knee" is reached. At this point, the zener breaks down and the voltage remains relatively constant over a wide current range.

However, the voltage does increase with increasing current and the slope of voltage against current is the zener impedance (or resistance). This impedance can range from 10Ω for low-value zener diodes to above 350Ω for 100V zener diodes.

Fig.1 highlights three operating conditions for a zener diode and the two of particular interest are maximum power and 10% of maximum power. These define the normal operating range of the zener. Note how the current/voltage slope is almost a straight line between these points.

At less than 10% of rated power, the zener voltage is much less than its rated value. On the other hand, operation at or above the maximum power rating will destroy the device (unless it is subjected to brief pulses of current).

In any case, zener diodes are not normally operated at maximum power since they must be de-rated for ambient temperatures above 25°C.

Note: some zener diode types have a very sharp "knee" which enables the diode to operate at very low currents, well below 10% of maximum power, while maintaining their rated breakdown voltage.

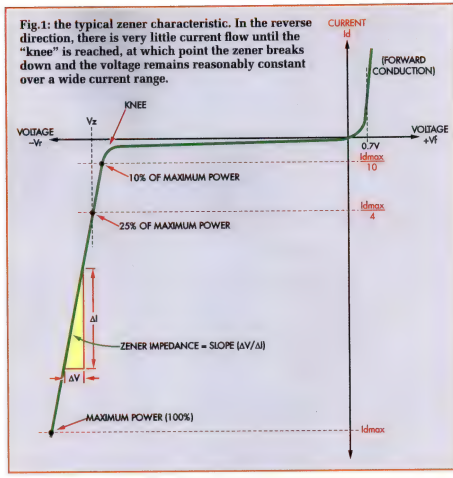


Fig.1: the typical zener characteristic. In the reverse direction, there is very little current flow until the "knee" is reached, at which point the zener breaks down and the voltage remains reasonably constant over a wide current range.

Testing zener diodes

Testing zeners might seem simple; just apply current so that it operates between 10% of maximum power and maximum power. That's done by supplying a voltage that's greater than the zener diode breakdown voltage and by limiting the current. However, in practice, it's not that simple.

Some zener testers apply a constant 5mA to the zener and then read off the value of breakdown voltage. That fixed current is suitable for the BZX79 series of zener diodes (or similar) that are specified for zener voltage at 5mA. That current applies for zener diodes ranging from 2.2V to 25V. A 2mA specification applies to zener diodes from 25V to 60V.

Other zener diodes are not characterised for 5mA and the current needed to test a low-voltage zener is vastly different to that required for a higher voltage type. In other words, a fixed 5mA is unsatisfactory, as we need to ensure that the test current runs the zener somewhere between the 10% and 100% power conditions.

The 1N5728 (4.7V) to 1N5757 (75V) series of 400mW zener diodes and the 1N4728 (2.2V) to 1N4764 (100V) series of 1W zener diodes are designed to operate at their specified zener voltage at a current that is 25% of maximum power. For a 3.3V 400mW diode, this equates to 30.3mA while for a 75V 400mW zener, the 25% condition is achieved at 5.3mA.

It will not matter too much if the current doesn't precisely give the 25% full-power rating since the breakdown voltage will only change slightly due to the zener impedance. But it is im-

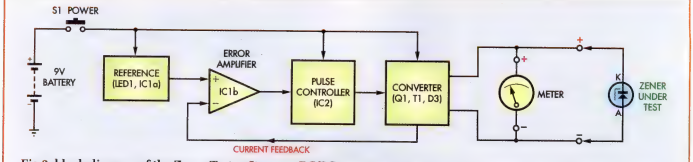


Fig.2: block diagram of the Zener Tester. It uses a DC/DC converter to step up the voltage from a 9V battery so that high-voltage zener diodes can be tested. The error amplifier and pulse controller ensure that a constant power is delivered to the zener diode under test, for a wide range of zener voltages.

portant that we do not drop below the zener knee.

Fig.8 (later in the article) shows the curves for both 1W and 400mW zener diodes for voltages from 2.5V to 100V. The lower two plots show the 40mW (10% of 400mW) and the 100mW (10% of 1W) power curves. The upper two traces show the maximum power curves for 400mW and 1W.

To properly test both 400mW and 1W diodes, we must have the zener diode operating between the 100mW and 400mW curves. In this way, we will be above the 10% power point and below their maximum limits for both wattage types. For our Zener Tester, the current typically follows the 200mW curve.

The constant 5mA current zener test is also shown on the graph. This reveals that in this condition, 400mW zener diodes below 8V operate at less than 10% of maximum power (ie, 40mW) while the maximum power rating is exceeded above 80V. For 1W zener diodes, the test power is below the minimum 100mW for any voltage rating below 20V. So the constant current method does not work well in practice.

Block diagram

The Zener Tester is based on a 9V to 125V DC-DC step-up converter. The block diagram is shown in Fig.2. It has four sections: a voltage reference, error amplifier, pulse controller and the converter itself.

Error amplifier IC1b monitors the current supplied to the converter and adjusts pulse controller IC2 to maintain a constant current to the converter from the 9V battery. The reference circuit also compensates for falling battery voltage as it discharges, so the power delivered to the converter and thus to the zener diode under test is also constant.

With the power being constant, this means that at high zener voltages, the output current is low and at low voltages, it is higher. A standard digital or analog multimeter can be used to read the zener voltage.

How it works

The full circuit for the Zener Tester is shown in Fig.3. IC2 is a 7555 timer configured as an astable oscillator to drive Mosfet Q1 with a square wave. This in turn drives step-up transformer T1. The output of the transformer is rectified by fast-recovery diode D3 and the resulting DC voltage is applied to the zener diode under test.

Error amplifier IC1b monitors the current through the 1Ω source resistor for Mosfet Q1. IC1b has a gain of 470 and it amplifies the difference between the feedback voltage at its pin 6 and the reference voltage at pin 5 to generate an error voltage. IC1b then drives pin 5 of the 7555 (its control voltage terminal) to modulate the output pulse width. The operating frequency of IC2 hovers around 67kHz.

If the current through Q1 is too high, IC1b pulls pin 5 of IC2 slightly lower, so that the width of the gate pulse fed to Q1 is reduced. This pulls the current back to the required level. Conversely, if the current is too low, IC1b pulls pin 5 of IC2 higher. This increases the duty cycle of the drive to Q1's gate and thus increases the current.

The reference voltage at the non-inverting input of IC1b (pin 5) is derived from a red LED via IC1a. Note that LK1 is installed if the power pushbutton switch used has no LED, in which case the reference voltage is provided by LED1 instead.

IC1a monitors the battery voltage via a voltage divider comprising 100kΩ and 1.2kΩ resistors, connected to its pin 2. The 100kΩ feedback resistors

Features & Specifications

Main Features

- Tests 400mW and 1W zener diodes
- Test range from 0.6V to 100V
- Constant power testing (about 200mW)
- Reading displayed using a digital multimeter
- Battery powered (9V)

Specifications

Diode test power: typically 200mW from 3.3V up to 30V, tapering to 150mW at 75V and 2.2V; 70mW at 100V.

Test power variation with supply voltage (6-9V): 0% (8.2V zener); 21% (3.3V zener); 12% (75V zener)

Battery current drain: from 51mA (9V) up to 84mA (6V)

Open circuit test voltage: ~125V

Short circuit output current: 100mA

connected to pins 1 & 2 give IC1a a gain of -1 for this signal path.

Similarly, the 1.8V across LED1 is divided using 100kΩ and 4.7kΩ resistors to give about 80mV at pin 3 of IC1a. IC1a then amplifies the difference by a factor of 2 (1 + 100kΩ / 100kΩ) to give 160mV.

To understand how this all works in practice, let's assume that the battery supply is 9V. In this case, the voltage across the 1.2kΩ resistor will be 106.7mV and so the output (pin 1) of IC1a will be at 160mV - 106.7mV = 53mV. However, if the power supply falls to 7.5V (for example), then the voltage across the 1.2kΩ resistor will be 89mV. The pin 1 output of IC1a will now be at 160mV - 89mV = 71mV.

Thus, as the supply voltage goes down, the reference voltage applied to pin 5 of IC1b goes up. This ensures that greater current is supplied with lower voltages, to maintain constant power. As the accompanying specifications panel shows, the scheme works well, with the power remaining constant for a supply of between 9V and 6V for an 8.2V zener diode.

Timer configuration

IC2 is configured in a slightly unusual way; the 1.5nF timing capacitor is charged and discharged directly from the output. Normally this results in a fixed 50% duty cycle. However, because IC1b overrides the control voltage, the oscillator ramp voltage is not necessarily symmetrical any more.

For example, if IC1b pulls the control voltage below the normal $^2/_3V_{CC}$, the 1.5nF capacitor charges faster than it discharges, because the voltage across the 6.8kΩ resistor is higher than usual when the output is high and lower than usual when it is low. As a result, the output duty cycle is lower. The reverse is also true and hence IC1b controls the duty cycle at Q1's gate.

Voltage limiting

Zener diodes ZD2 & ZD3 limit the voltage spike which occurs at the drain of Mosfet Q1 each time it switches off. What happens is that as the drain voltage rises above about 54V, zener diodes ZD2 and ZD3 begin to conduct and pull the gate of Q1 above 0V.

This switches on Q1 to suppress any excess voltage and so the drain voltage is limited to a value which is the sum of the voltages across ZD2, ZD3, diode D2 and the gate on-threshold voltage.

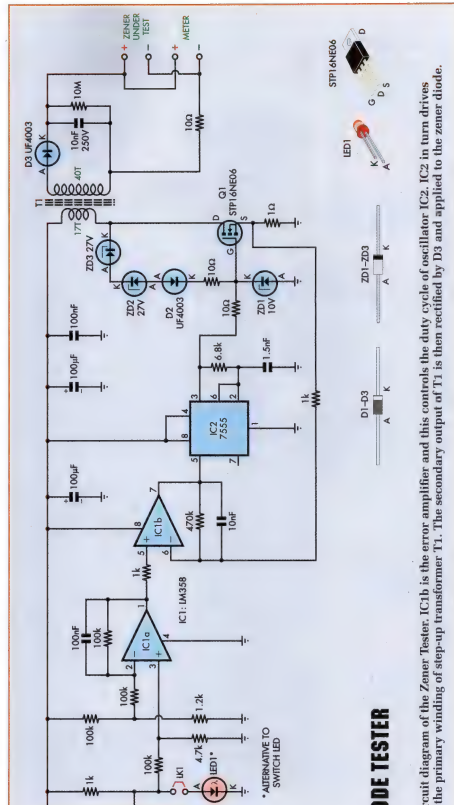


Fig.3: the complete circuit diagram of the Zener Tester. IC1b is the error amplifier and this controls the duty cycle of oscillator IC2. IC2 in turn drives Q1, and this switches the primary winding of step-up transformer T1. The secondary output of T1 is then rectified by D3 and applied to the zener diode.

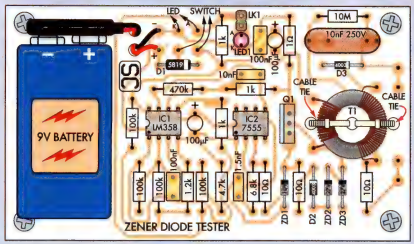


Fig.4: install the parts on the PCB as shown here, taking care to ensure that all polarised parts (including toroidal transformer T1) are correctly orientated. The two ICs can be directly soldered to the PCB.

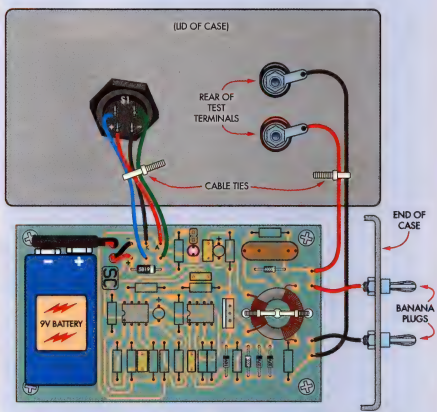


Fig.5: the switch, binding posts and banana plugs are connected to PC stakes on the PCB via medium-duty hook-up wire. Use heatshrink tubing over the PC stake connections and at the ends of the binding posts to stop the connections from breaking due to vibration.

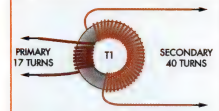


Fig.6: T1 is wound using 0.25mm enamelled copper wire with 17 turns for the primary and 40 turns for the secondary. The winding direction is important, so follow the way the windings are shown for both the primary and the secondary.

Typically, this will be just over 60V and this in turn limits the maximum voltage that can be delivered by the transformer's secondary winding (with no zener diode connected across the test terminals) to something less than 145V.

In practice though, the limit appears to be about 115V (depending on the battery condition).

Power supply

Power for the circuit is derived from a 9V battery via reverse polarity protection diode D1 and pushbutton switch S1. The battery condition is indicated by the brightness of the LED. If LED1 is dim, then it's time to change the battery. The fact that the circuit works below 6V means that battery life is good.

An alternative battery check is to measure the output voltage when the Zener Tester is plugged into the multimeter, without anything connected across the terminals. If the output is above 100V then the battery condition is satisfactory.

Construction

Construction of the Zener Tester is straightforward, with most of the parts mounted on a PCB coded 04111111 and measuring 61 x 107mm. This is housed in a plastic utility box measuring 130 x 68 x 44mm. The PCB clips into slots moulded into the sides of the case. Corner mounting holes are provided on the PCB for other applications.

Check the board for faults and repair it if necessary. Also check that the PCB mounting holes and the holes for the battery leads are the right size (3mm).

Fig.4 shows the assembly details. Begin by fitting all resistors. The resistor colour code table can be used to read their values however it's best to check them with a digital multimeter in Ohms mode.

The diodes, including zener diodes ZD1-ZD3, can then be installed and must be mounted with the orientations shown. Note also that D1 is a 1N5819, while D2 and D3 are UF4003 or 1N4936 types. There are two different zener diode types (10V & 27V) so don't get them mixed up.

IC1 & IC2 go in next. 8-pin DIL sockets may be used but are not necessary; the ICs can be soldered the PCB.

In either case, take care to orientate them correctly, with the notch/dot positioned as shown.

Solder the PC stakes next, then the capacitors. The electrolytic types must be orientated with the correct polarity, ie, longest lead through the hole marked "+".

LED1 is mounted flush against the PCB (it's there to provide a reference voltage only). Make sure the anode (longer lead) is placed in the hole marked "A".

That done, the 2-way pin header can be installed, followed by Mosfet Q1 which is installed vertically. Be sure to orientate Q1 as shown.

Winding the transformer

T1 is wound as shown in Fig.6. It uses 0.25mm enamelled copper wire with 17 turns for the primary and 40 turns for the secondary. The winding direction is important so follow the way the windings are shown on Fig.6 for both the primary and the secondary.

When winding is completed, the transformer can be installed on the PCB. Use a sharp knife or emery paper to strip the enamel insulation at each end of both wires, then tin them and solder them to the appropriate PCB pads. The transformer is held in place with cable ties that pass through holes in the PCB.

Preparing the case

Use the front panel artwork (Fig.7) as a guide to drill the holes in the lid for the switch and binding posts. Start with a small pilot drill, then enlarge the holes and ream them out to the correct size. The binding post holes must be 8mm in diameter but the switch hole will depend on the switch used.

You also need to make holes in the end of the box for the banana plugs, with the standard 19mm spacing. These go 12mm down from the top edge of the box. Drill the holes out smaller than the screw thread of the banana plugs so that these can be screwed into the plastic box, forming a thread in the process.

Finally, a 3mm hole is also required for the battery holder screw support in the opposite end of the box. This hole is positioned 13mm down from the top edge of the box, then countersunk on the outside.

The next step is to prepare the front panel label. This can be downloaded from the SILICON CHIP website (in the November 2011 downloads section) or

This is the view inside the case after the wiring has been completed. The metal battery holder is secured to the side of the case using an M3 x 9mm tapped spacer and machine screws.

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
10nF	0.01µF	10n	103
1.5nF	.0015µF	1n5	152

Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	4	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	6.8kΩ	blue grey red brown	blue grey black brown brown
❑	1	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	1.2kΩ	brown red red brown	brown red black brown brown
❑	3	1kΩ	brown black red brown	brown black black brown brown
❑	3	10Ω	brown black black brown	brown black black gold brown
❑	1	1Ω	brown black gold brown	brown black black silver brown

These waveforms illustrate the operation of the step-up converter. The yellow trace is the waveform fed to the gate of Mosfet Q1. Each time the gate signal goes positive, the Mosfet turns on and its drain is pulled low, as shown by the green trace. As the gate pulse goes low again, the Mosfet turns off and the drain voltage swings high and rings at a high frequency, producing a peak voltage of around 60V. This is stepped up in the transformer and rectified by diode D3 to charge the 10nF capacitor. When the diode stops conducting, the ringing at the drain continues at a lower frequency until the Mosfet is switched back on by the next positive gate pulse.

photocopied from this article.

You can either print it onto paper and laminate it, or print it onto sticky-backed photo paper or plastic film. When using clear plastic film (ie, overhead projector film) you can print the label as a mirror image so that the ink is behind the film when placed onto the panel.

Once the label is in place, use a hobby knife to cut out the holes.

If it isn't self-adhesive, affix it to the panel using an even smear of neutral cure silicone sealant or spray contact adhesive. For plastic film, if you are affixing to a black coloured panel, use coloured silicone such as grey or white so that the label can be seen against the black.

Wiring

Begin the wiring by removing the banana plugs, then solder short lengths of hook-up wire to the rear of each one (if you solder it with them in the box, the box will melt). That done, screw them back in, allowing the wires to rotate freely as you do so, so they don't get twisted.

Fig.5 shows how the wiring is done. The 9V battery leads are looped through the holes in the PCB and then soldered to the PC stakes with heatshrink tubing over the soldered joint. It's important to loop the wire through the holes provided in the PCB, to improve retention and to prevent the wires from breaking off the PC stakes when the battery is changed.

The wiring shown assumes switch S1 has an integral LED. If not, simply omit the two additional wires. Use regular hook-up wire for the connections and as with the battery, heatshrink the joints to the PC stakes as well as where the wires join to the binding posts.

Parts List: Zener Diode Tester

1 PCB, code 04111111, 61 x 107mm
1 plastic utility box, 130 x 68 x 44mm
1 9V alkaline battery
2 banana line plugs
1 red binding post
1 black binding post
1 9V battery clip connector
1 9V battery holder (Jaycar PH-9237, Altronics S5050)
1 momentary push-on switch with red LED indicator (Jaycar SP-0706, Altronics S1086) (S1) OR 1 momentary pushbutton switch
1 ferrite toroid, 18 x 10 x 6mm (Jaycar LO-1230 or equivalent)
1 1.3m length of 0.25mm enamelled copper wire
1 M3 x 6mm panhead screw
1 M3 x 6mm countersunk screw
1 9mm M3 tapped spacer
1 2-pin header (2.54mm pitch)
1 shorting plug for header (LK1)
10 PC stakes
4 100mm cable ties
1 100mm length of 3mm-diameter heatshrink tubing
1 30mm length of 5mm-diameter heatshrink tubing
200mm of red hook-up wire
200mm of black hook-up wire
120mm of white hookup wire

Semiconductors

1 LM358 dual op amp (IC1)
1 7555 CMOS timer (IC2)
1 STP16NE06 60V Mosfet (Q1)
1 1N5819 Schottky diode (D1)
2 1N4936 or UF4003 fast recovery diodes (D2, D3)
1 10V zener diode (ZD1)
2 27V 1W zener diodes (1N4750; ZD2, ZD3)
1 3mm red LED (LED1)

Capacitors

2 100µF 16V PC electrolytic
2 100nF MKT
1 10nF 275VAC X2 class MKP
1 10nF MKT
1 1.5nF MKT

Resistors (0.25W, 1%)

1 10MΩ
1 470kΩ
4 100kΩ
1 6.8kΩ
1 4.7kΩ
1 1.2kΩ
3 1kΩ
3 10Ω
1 1Ω 5%

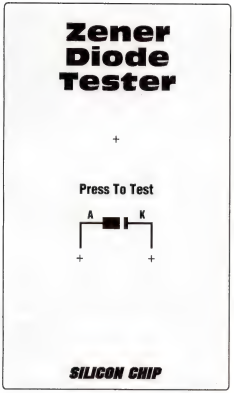


Fig.7: this artwork can be copied and used as a drilling template for the front panel. It's also available in PDF format from our website, to make a front panel label.

Once the wiring is complete, secure it using cable ties as shown.

With the board in place and wired up, install the battery holder. Use a machine screw to connect the 9V battery clip to the M3 tapped spacer, then attach the other end of the spacer to the box using an M3 countersunk screw.

Testing

If you are not using a power switch with integral LED, install a shorting block on LK1. Otherwise, leave it out. Press S1 and check that the LED lights. If not, check the LED and switch wiring. The LED may be wired or installed backwards.

Now plug the unit into a multimeter and set it to read DC volts. Press power button S1 and check that the output produces 115-125VDC. If not, check that T1 is wound correctly, as shown in Fig.6. You can swap the two primary connections if necessary; there is no need to rewind it if it is wrong.

If it still doesn't work, check other voltages on the circuit. The supply for IC1 (between pins 8 & 4) and IC2 (between pins 8 & 1) should be about 0.3V less than the battery voltage. Check for around 80mV at pin 3 of IC1a.

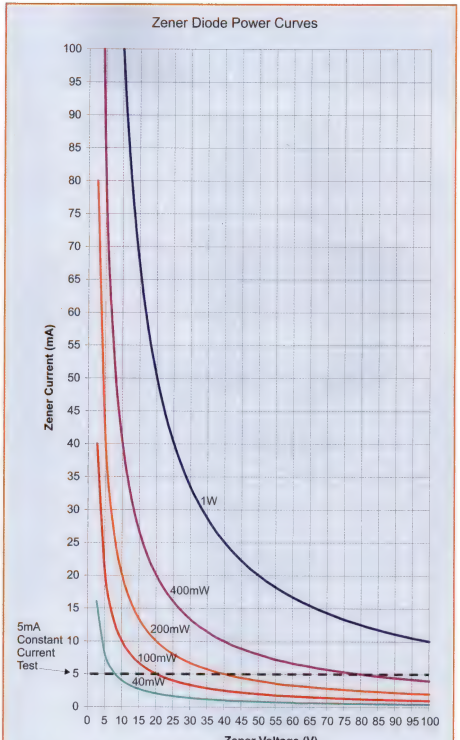


Fig.8: the voltage versus current curves for both 1W and 400mW zener diodes for voltages from 2.5 to 100V. The lower two traces show the 40mW (10% of 400mW) and the 100mW (10% of 1W) power curves. Our Zener Tester typically follows the 200mW power curve.

To check operation of the Zener Diode Tester under load, connect a 1kΩ resistor across the test terminals. The multimeter should indicate a reading of about 14V. This means that close to 200mW ($14V^2 \div 1k\Omega$) is being delivered to the resistor.

Further testing can be done using zener diodes with known breakdown voltages.

Note that zener diodes can have a tolerance of 10%, 5%, 2% or 1% and that the measured voltage can also depend on the zener current. SC

Vintage Radio

By Rodney Champness, VK3UG

The Astor P7G 8-Transistor AM Portable Radio

Australian manufacturers built some excellent transistor radios during the early-to-mid-1960s. The Astor P7G was one such set. It boasted no less than eight transistors and even included an RF stage to lower noise and boost sensitivity.

DOMESTIC TRANSISTOR RADIO manufacture in Australia commenced in the late 1950s. The first sets were built in much the same way as valve radios. Point-to-point wiring was common (ie, they didn't use printed circuit boards) and in some cases, the transistors were plugged into sockets just like valves had always been installed.

By contrast, the Japanese started with crude printed circuit boards (PCBs) right from the onset of transistorised receiver manufacture. As a result, Australian manufacturers initially lagged behind the Japanese in their construction techniques before adopting phenolic printed circuit boards.

Like many, I wasn't initially all that keen on PCBs as it was often difficult to be sure which track a particular component was wired to. Instead of following point-to-point wiring, you had to try to work out the connections by examining both sides of the board and this could be rather difficult on a tightly-packed board.

Apart from that, early PCBs also suffered from a number of drawbacks. They were somewhat hygroscopic (ie, they absorbed moisture), were easily charred if components overheated and the copper tracks lifted off the board if too much heat was used during soldering.

Hairline cracks in the tracks were also common and caused many intermittent faults. They were almost impossible to see and if a serviceman suspected such a problem, the cure was to run solder right along the suspect track. This sometimes involved laying a very thin wire strand along the suspect track and soldering it at various intervals until the fault vanished.

These servicing techniques largely overcame the problems with early boards. And of course, as time went by, the various issues were addressed and the quality and durability of the boards improved.

Japanese receivers

The performance of the early Japanese transistors receivers wasn't all that good. They were noisy and not very sensitive and that situation continued for many years.

Of course, the Japanese were catering for a world market where listeners generally lived close to local radio stations. By contrast, many Australians lived some distance away from radio stations, so sensitivity was important.

As a result, Australian manufacturers produced many sensitive, low-noise receivers to suit the domestic market. However, despite their technical superiority, they eventually lost the battle for market share due to the low cost of imported receivers. As a result, domestic receiver production slowed and eventually ceased in the 1970s.

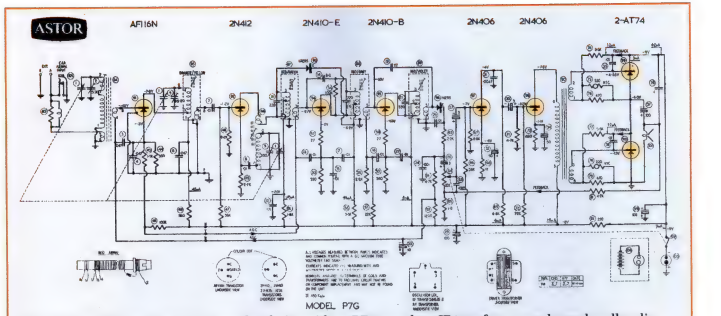


Fig.1: the circuit is an 8-transistor superhet design with an RF stage, three IF transformers and a push-pull audio output stage. It uses an internal loopstick antenna but provision is also made for an external antenna.

There was no point making receivers if no one bought them, even if they were superior in many respects!

Astor P7G transistor receiver

One good-quality Australian set from the early transistor era was the Astor P7G. This was an 8-transistor broadcast band portable and was produced around 1965.

I came across the Astor P7G receiver described here at a swap meet. On inspection, I found it to be quite clean both inside and out and because it had an RF (radio frequency) stage, I thought that it would be a very good performer.

The 276-P battery had been left in the set but had not leaked and no corrosion was evident. So as a bonus I got a battery that I could use for display purposes.

As shown in the photos, the set is housed in a stitched brown leatherette case which measures 250 x 180 x 80mm (W x H x D) although this doesn't include the handle and knobs. It weighs a hefty 2.2kg with the battery installed.

The dial scale is a normal slide-rule type and the tuning was still firm and positive, so the dial system was well thought out and executed. The tuning control is at the right-hand end of the cabinet while the on-off volume control is at the other end.

Like many sets of this calibre, it has provision for an external antenna and earth via two flat-headed screws on the top edge of the back panel. In addition, for those who wanted to use the set in a car, Astor provided a socket to suit a car radio antenna cable at the left-hand end of the cabinet, below the volume control.

To gain access to the battery, it is necessary to loosen a flat-headed screw at the lower edge of the back of the cabinet and then lift the back flap up. The 276-P 9V battery is held in place by a small clip arrangement, which is easily sprung open to allow the battery to be removed.

Another excellent feature is that all the alignment adjustments are accessible without taking the chassis out of the cabinet. In addition, most of the alignment points are marked either with colours or numbers which are also shown on the circuit.

Circuit details

Fig.1 shows the circuit details of the Astor P7G. As stated, it's an 8-transistor design that includes an RF stage to ensure good sensitivity and low noise. As such, it outperforms almost all Japanese transistor receivers of the same era.

The input circuit consists of a ferrite-rod loopstick antenna measuring 12.7mm in diameter and 203mm long. This has three windings on it, with the tunable winding spread along about half its length. One end of this winding is earthed, while the other has another, much smaller coil wired in series with it.

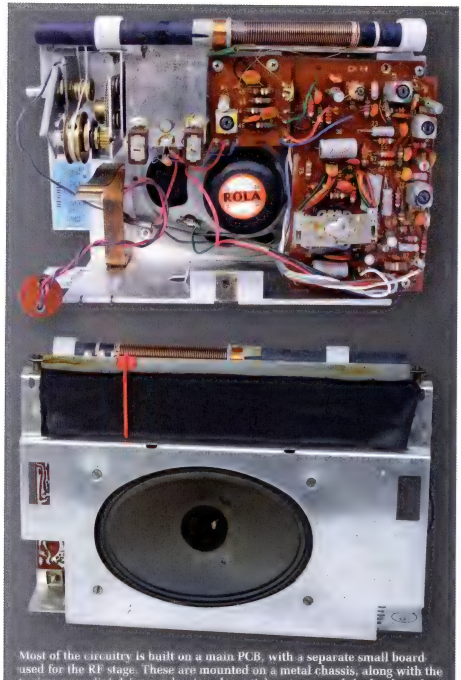
This latter winding is on a small former and is slid along the ferrite rod to tune the antenna circuit for best performance at the low-frequency end of the tuning range.

Another small winding is interwound with the tuned winding at the earthed end and this is connected to the base of the RF transistor. And finally, there is a small winding positioned about 8mm down from the earthed end of the tuned winding. This is attached to the chassis at one end, while the other end is connected via a parallel choke-resistor combination (component 83) to two antenna inputs: (1) a coaxial cable input socket for use with a car radio antenna; and (2) an input for a normal long-wire antenna which is connected to the "A" terminal on the back of the receiver's case.

Note that when "A" is used, the corresponding "E" terminal must be connected to an earth, otherwise the improvement in performance when an antenna is connected will only be slight.

It may seem strange that an RF choke and a resistor are used in series with the antenna. In fact, you would expect that this would attenuate the signal going to the coupling coil on the ferrite rod.

However, the reverse is true – it actually boosts the signal. Basically, the choke acts as a series loading coil which tunes the antenna system (assuming an "average" antenna) to just below the broadcast band. This boosts the performance at the low-frequency



Most of the circuitry is built on a main PCB, with a separate small board used for the RF stage. These are mounted on a metal chassis, along with the tuning gang, dial-drive mechanism, loopstick antenna and the loudspeaker.

end of the broadcast band, as an external antenna is usually very short compared to a tuned length.

At the high-frequency end, the antenna more nearly approaches a tuned length so the performance of the antenna is better there. In fact, the performance under some circumstances could be so enhanced that the sensitivity across the broadcast band would be very uneven.

To overcome this, the choke is shunted with a resistor. This damps the effect of the choke so that the sensitivity at the low-frequency end of the band is similar to that at the high-frequency end.

The first amplifying stage is an AF116N, one of the later low-noise germanium PNP RF transistors. Note that the transistor symbols used in the circuit diagram are different to those now in use. They were commonly used in the 1960s and were later superseded.

The output of the AF116N appears at its collector and is fed through a broadcast-band tuned circuit to the input of an autodyne oscillator mixer based on a 2N412 PNP transistor. The collector of this stage connects to a feedback winding for the oscillator circuit and this then goes to the primary of the first 455kHz IF transformer.

The first IF amplifier stage uses a 2N410-E. Its output is applied via the second IF transformer to a second IF amplifier, this time based on a 2N410-B. The output of this stage is then fed through a third IF transformer to the detector which is a 1N295 germanium diode.

The resulting audio output is fed via a volume control pot (which also includes an on/off switch) to the base of a 2N406 amplifier. This stage drives a second audio amplifier stage (also using a 2N406) and this in turn drives a push-pull output stage via a driver transformer.

The output stage is based on two AT74 output transistors and these drive an oval-shaped (127 x 100mm) 15-ohm loudspeaker. Negative feedback is applied from the top of the loudspeaker to the bottom of the volume control which is connected to ground via a 1.8Ω resistor (65).

Temperature compensation

Germanium transistors, particularly those used in the output stage of a receiver, need to have their standing current stabilised to prevent thermal runaway. Without this stabilisation, the transistors will draw more and more current as they heat up until eventually thermal runaway occurs and the transistors fail.

In the Astor P7G, thermal compensation is achieved using 220Ω NTC (negative temperature coefficient) thermistors (75) and (78). As the temperature of the transistor junctions increases, their resistance decreases. This in turn reduces the forward bias applied to the output transistors and thus controls the quiescent current through them under no signal conditions.

Automatic gain control

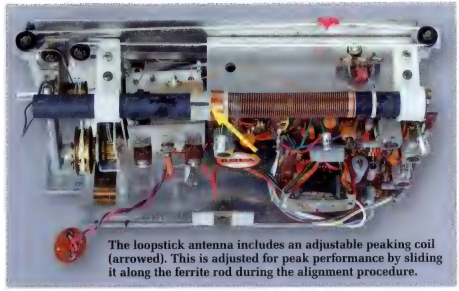
Automatic gain control (AGC) is applied in a variety of ways in transistor receivers and is usually more complex than in valve receivers. The gain of transistors can be controlled by biasing them closer to cut-off or by biasing them to draw more current (which lowers their gain).

In this receiver, increased signal levels cause the output of the detector (96) to go more positive. This in turn

applies progressively more positive voltage (via a voltage divider) to the base of the PNP AF116N RF amplifier, causing it to draw less current. This stage in turn biases the following first IF amplifier stage (2N410-E), which also then draws less current.

This means that there will be less voltage drop across resistor (55) and this causes the associated 1N295 diode (93) to conduct. As a result, this diode acts as a variable shunt across the first IF transformer and thus reduces the signal level applied to the first amplifier IF stage.

This makes a very effective AGC system and is very different to the AGC methods used in valve receivers.



The loopstick antenna includes an adjustable peaking coil (arrowed). This is adjusted for peak performance by sliding it along the ferrite rod during the alignment procedure.

Restoring the cabinet

Removing the chassis from the cabinet proved to be much more difficult than expected. First, I removed the two knobs, then the screw in the middle of the bottom of the cabinet that secured that section of the chassis in place. The screws securing the handle to the cabinet were then removed, along with the two "A" antenna and "E" earth screws.

That done, I attempted to remove the chassis but it seemed to be jammed in place. I thought that perhaps the car radio antenna socket was somehow fouling the chassis removal so I removed the four screws holding the main circuit board in place and lifted it out of the way. All that did was show that it wasn't the socket that was causing the problem.

It was difficult to see what was causing the problem as the chassis is tucked quite tightly into the cabinet. I then observed two screws, one in the top left-hand corner of the cabinet and another in the top right-hand corner. These two screws were buried deep in the set against the front panel.

Initially, I thought that these held the dial system in place but I was getting desperate so I removed them anyway. And that was it – the chassis could now be removed with a little encouragement, although I did have to disconnect the four wires that ran from the chassis to the antenna and earth connections.

With the chassis now out of the way, I tried cleaning the cabinet using a soft cloth dampened with water (as suggested in the service data). However, this had little impact on the 45 years of grime on the surface, so I adopted a more aggressive approach, this time using a nailbrush dipped in a solution of dishwashing liquid in warm water.

This method removed almost all the greasy gunk from the cabinet surface, after which the cabinet was left to dry in the sun. It was a matter of knowing when to stop as the inner section is made of a form of cardboard, so it was important not to get it wet.

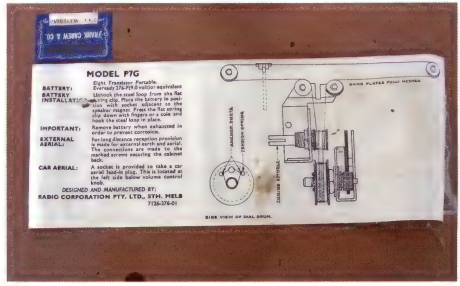
I also found a number of greasy marks and dirt along the metal front panel. This was also scrubbed using a nailbrush and it now looks very acceptable. The cabinet now looks quite good even though some of the stitching along the cabinet edges has given way over the years.

Restoring the chassis

A quick inspection revealed that the printed circuit boards were in good condition, with no sign of overheating or damaged components. It was time to see if it worked, so I connected a low-voltage variable DC power supply to the battery plug, with a milliammeter in series with one lead. I increased the voltage slowly and the current gradually increased to about 10mA at 9V which is normal.

At this stage, the receiver was working but its sensitivity wasn't good and the volume occasionally "jumped" up and down. I tapped lightly around the circuit board with the back end of a small screwdriver and the volume varied as I did so, indicating a possible dry solder joint. It was especially sensitive when I touched the third IF transformer.

With the location of the fault nar-



The inside back of the cabinet includes a diagram that shows the dial-string arrangement plus information on the battery and antenna connections.

The old Astor P7G's leatherette cabinet is still in good condition, although the stitching is starting to give way in some places. The antenna and earth terminal screws are at top right and top left respectively.

rowed down, I checked at the underside of the board using a headset magnifier. This revealed that at least one pin of the third IF transformer had a dry solder joint. It looked tarnished so I used de-soldering braid to remove the solder from all the pins of this transformer, then scraped away any tarnish until all the pins were shiny.

I then resoldered all the pins and that fixed the intermittent volume changes. There were no other problems apart from the fact that the set needed an alignment. And to do that, I first had to reinstall the chassis in the cabinet and reconnect the leads I had disconnected earlier.

With a little coaxing, the chassis slipped into place and the three retaining screws were refitted. The top corner screws were installed using a magnetic screwdriver. This allowed me to keep the screws in place at the end of the screwdriver while I carefully guided them into the cabinet.

Alignment

Assuming that the various adjustments have not been twiddled with aimlessly by someone in the past, the alignment procedure should always be straightforward.

As stated, with this set, it's possible to access all the tuning adjustments with the chassis in its cabinet. The IF section is quite easy to align – just tune the receiver to a weak station and use a small-bladed screwdriver to adjust the three slugs in the IF transformers for best performance (the metal blade of the screwdriver material does not appear to upset any of the adjustments).

In this case, only slight adjustments were necessary to tune the IF transformers for peak performance.

By contrast, the RF, antenna and oscillator adjustments need more care if accurate alignment is to be achieved. Thankfully, the dial pointer was where it was supposed to be when the gang was fully closed, otherwise I would have had to remove the chassis again to move it to its correct position.

Having checked that, I tuned to a strong station near the low-frequency end of the band and adjusted the oscillator coil so that it appeared in the correct location on the dial. I then tuned to a strong station near the high-frequency end and adjusted the wire trimmer so that the station appeared in its correct location. There is some interaction between these two adjustments, so they were repeated a few times until everything was correct.

That done, I tuned to a weak station at the low-frequency end and adjusted the RF coil and antenna peaking coils for best performance (the latter is simply slid along the ferrite rod). After that, the trimmer capacitors were peaked for best performance at the high-frequency end and this procedure was also repeated a few times until the performance was as good as could be expected.

By the way, the MSP 3-gang (and 2-gang) "padder-less" tuning capacitors used in this set and many other transistor and valve receivers of the era had to be accurately matched to the inductances and distributed capacitance in the front-end tuned circuits. If this was not done, receivers using these gangs did not track accurately.

A number of receivers didn't get this matching quite right and so suffer from this problem. Fortunately, Astor seem to have got it as close as practicable in the P7G.

Power supply

The Astor P7G was originally powered by a 276-P 9V battery which fitted in the bottom left-hand corner of the chassis, as viewed from the back. These batteries are no longer readily available but this can be solved in various transistor sets by fitting a replacement battery pack. This can simply be a single 216 9V battery if it is a very small set, or a battery can be made up using AA, C or D cells as required.

For the Astor P7G, I used a 6-pack of AA cells and soldered the leads from this battery to the 2-pin battery plug. I then covered the exposed pins of the plug with heatshrink tubing and wound insulation tape around the pack to keep it intact. Finally, the battery was installed along with some foam insulation, so that it would fit snugly.

With the 276-P, the battery life was about 300 hours but is only about 100 hours with the AA-cell pack. The current drain with no audio output is around 10mA and about 25-50mA for normal listening. It can go as high as 150mA if the volume is wound right up though.

Summary

The Astor P7G is a good example of the high-performance transistor receivers that were built by Australian manufacturers during the 1960s. In fact, its performance is similar to the more upmarket and expensive AWA B32 transistor receiver that was described in the August 2005 issue.

One curiosity is that the RF stage is built on a separate board to the rest of the receiver. It's possible that a cheaper version of this set was also available without the RF stage, although I haven't been able to confirm that.

Servicing this set is not as easy as it could have been but apart from that, it's an excellent design. SC

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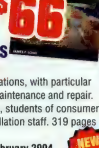

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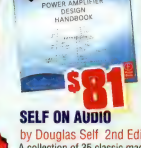

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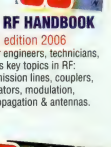

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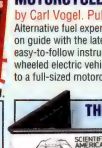

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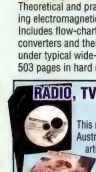

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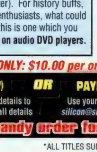

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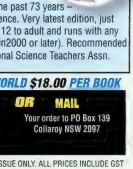

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Can 12V amplifier run on reduced voltage?

I have recently purchased the 12V Mini Stereo Amplifier from Jaycar (Cat. KC-5495, SILICON CHIP, May 2010). Will this amplifier run with a guitar as the input source and if so, will 9V be enough? (R. E., via email).

● While the amplifier will run from 9V, it won't develop much power and a typical small 9V battery will not last very long powering it.

We recommend that you instead use a small 12V gel cell (sealed lead acid) battery. The best value is Jaycar SB2486 (7.2Ah, $24.95) and this will allow the amplifier to deliver reasonable power; probably all day, depending on how hard it is driven.

Its weight is 2.2kg though. If you need something lighter you can try the Jaycar SB2480 (1.3Ah, $19.95) which weighs about 570g but this may only last a couple of hours; possibly more if the output is not very loud.

These can be charged using virtually any lead-acid battery charger but some care must be taken to avoid overcharging them. Jaycar sell a number of suitable chargers (eg, MB3517 or MB3526).

As for plugging a guitar in directly, it depends to some extent on the type of pick-up but usually guitars have a relatively high output impedance and a low signal level. You can certainly try plugging a guitar directly into the amplifier and you should get some sound out but it may be too quiet for your liking. Changing the volume potentiometer to a 100kΩ logarithmic type will increase the input impedance of the amplifier and that may help.

If it is still too quiet then you will need to add a preamplifier between the guitar and the amplifier (it could be built into the same case). One possible candidate would be the High-Performance Microphone Preamplifier published in the September 2010 issue (Altronics kit Cat. K5514). This provides adjustable gain from 3-111 and is quite small so could be fit into the amplifier case.

Connect the guitar input to the microphone preamplifier input, then the microphone preamplifier output to the amplifier board inputs. It can run off the same power supply. The preamp gain knob does not need to be accessible outside the case as you can still use the volume knob.

We have also published various guitar mixers and other suitable preamplifier projects in the past. The latest one is the Versatile 4-Channel Guitar Mixer published in June 2007 which is available as a kit from Altronics (Cat K-5353) and Jaycar (Cat KC-5448).

Queries on the 6-Digit GPS Clock

I have just built the 6-digit GPS Clock and I have a couple of questions about this project. First, the PCB has a track linking pins 26 & 33 of the PIC, ie, RC7 is linked to RB0/Int but the circuit diagram does not show this. Have I missed some essential point or errata?

Second, I am using a different GPS module. It is an EM411 which is a 5V module. How do I interface this module to the PIC? Can I take the output signal from the 411 straight to pin 26 on the PIC or do I need to modify the inverter on the GPS module circuit board? If so, what is needed? (M. G., via email).

● Pin 26 of the PIC does connect to pin 33, as you point out. This was done purely for convenience in the PCB design, when running the track around to the collector of Q21. This does not cause a problem as pin 33 (RB0) is configured as an input and is ignored by the firmware.

We don't see any problem in using a 5V GPS module with the clock but we suggest retaining the inverter on the GPS module board and simply changing the value of Q1's collector load resistor to 1.5kΩ. This will avoid any possible problems related to the voltage levels of the NMEA output from your GPS module.

12/24V MPPT Solar Controller

I have just assembled the Solar Charge Controller (SILICON CHIP, February 2011) and fitted the extra components so that I can use it on 24V. Unfortunately, it does not work.

I adjusted the 5V on TP5V then I measured the battery voltage (26V) and multiplied it by 0.3125 = 8.125V, as per the "setting up" instructions but when I tried to adjust VR3 to that

Speed Controller Replacement For Golf Buggies

We repair a lot of older golf trundlers and our biggest problem is obtaining replacement motor controllers. The 12/24V 20A DC Speed Controller project designed by John Clarke (SILICON CHIP, June 2011) fits the bill but would the TL494 drive four Mosfets? (H. R., New Plymouth, NZ).

● You should be able to drive four Mosfets from the emitter of Q3 via separate 47Ω gate resistors. The more Mosfets, the slower the gate rise and fall times will be, due to the extra gate capacitance.

Since the operating frequency is low, the slowed gate drive should not matter. We obtained reasonably fast 1.5µs and 1.6µs gate rise and fall times with two Mosfets so four should not cause the rise/fall time to be more than about 3µs.

The 15V zener diode between gate and source should be included for each Mosfet. Alternatively, use higher-rated Mosfets so that less Mosfets are required. Note that the speed controller circuit does not have feedback to maintain motor speed under load.

GPS For Surveying & Controlling Farm Machinery

I have found your articles on GPS modules interesting. I was wondering if you might consider a project with two GPS modules communicating together, one being a set reference point. A person could get an accurate GPS map of properties if one unit is on a set grid reference like the surveyors do. (M. A., Hobart, Tas).

● We put your question and also another involving using GPS to guide tractors for ploughing etc to Geoff Graham, who has designed a number of our GPS projects. His comments follow:

The problem with using a GPS as a surveying tool is that they are not accurate enough to precisely locate surveying points. Often GPS systems are described as being accurate to a few metres but that is a best case result; the guaranteed accuracy is more like 10 metres. With one GPS located nearby at a precise point and transmitting a correcting signal to the other GPS, you could get even better accuracy but it would still be difficult to get an accuracy of better than 2-3 metres.

Professional surveyors may use such a set-up but they are likely to have some other tricks up their sleeves, as an error of 2-3 metres would be too large for surveying work. Also, I doubt that it would be good enough for automated farm machinery.

amount all I could get was about 7.5V! I wonder if that figure (0.3125) is different for 24V? There is no reference of anything other than 0.3125 for 12V so I used it for 24V!

Then I plugged in IC1 and fired it up again but no charging current was going into the battery. About this time I noticed that inductor L1 has 7 turns = 5mH for 12V but when using on 24V a 10mH inductor should be used. How many turns should I have? If 7 turns = 5mH, does 14 turns = 10mH?

One other thing, if this controller is like most others, you should always connect the battery first, then the solar panels, otherwise the (high) OCV (open-circuit voltage) from the PVs may damage the controller. Your wording under "Installing TH1 & S1" says it's just a matter of connecting the PANEL and the BATTERY. The reverse order might be better!

I hope you don't mind me pointing out these problems and do you have any answer to why my controller won't go? (M. L., Dunedin, NZ).

● Details on how to use the Charge Controller on 24V are shown in the panel on page 47 of the February 2011 issue, ie, "Using 24V Batteries & Solar Panels". As stated, the divider for 24V is 0.15625 rather than 0.3125 and the number of turns for L1 is increased from 7 to 10.

If you set trimpot VR3 with the divider set to 0.3125, the charger would be receiving a voltage that would suggest the battery was fully charged. Changing the divider to 0.15625 should have the charger working.

It does not matter if the solar panel is connected before connecting the battery.

Buffers ensure fast rise and fall times

I have just built your 10A/230VAC Motor Speed Controller (Silicon Chip, May 2009). It works very well as a general-purpose controller but I would like to modify it slightly and optimise it to permanently control a single workshop machine.

Your article describes the circuit fairly clearly and I have been able to plan the electrical and physical changes I need to make. I have tested some of these and all seems fine. However, I don't understand one part of the circuit and before proceeding with the rest of my modifications I would like to clarify this section.

The component in question is the 4050B hex CMOS buffer, marked as IC2 on the circuit diagram. I am puzzled by the way you use this chip. Why do you need to have a two-stage buffer with IC2c in series with the rest? Even more puzzling, why do you need three buffers in parallel (IC2b, IC2e and IC2f) to drive the bases of a couple of small signal transistors? Why can't you just use a single non-inverting buffer and be done with it? A single buffer provides plenty of current according to the chip's specifications.

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Running Ultrasonic Anti-Fouling From Shore Power

I purchased the Jaycar kit of your Ultrasonic Anti-Fouling Unit (SILICON CHIP, November & December 2010). I would like to run it from 240V AC shore power. What power supply would you suggest?

I tried Jaycar SMPS 25W and 40W versions but both of these don't do very well after they have warmed up. Should I build something else? I guess it is the start-up current or something causing the SMPS to fault? Any suggestions would be greatly appreciated. (J. R., via email).

● The peak currents drawn by the Ultrasonic Anti-Fouling Unit's driver will cause the SMPS to shut down periodically. A linear power supply capable of delivering 3A peak could be used but presumably your boat already has a "house battery" which is normally on float charge from a battery charger which runs from shore power. If so, then run your Ultrasonic Anti-Fouling unit from that. If you don't have your boat's batteries running on permanent float charge, you really should get yourself such a charger.

Alternatively, you could run the Ultrasonic Anti-Fouling Unit from a separate small 12V battery with its own float charger which is run from shore power. The charger would need to be able to deliver more than 500mA while the battery can be quite small, such as a 4.2Ah 12V SLA type.

If the problem is floating inputs and outputs on unused gates, why not just tie them high (or low) as appropriate? What am I missing here? (J. M., via email).

● The 4050 buffers ensure a fast rise and fall time for the IGBT gate drive. These provide sufficient drive current to drive transistors Q2 and Q3 which, in turn, drive the IGBT's gate. While a single non-inverting buffer would work, paralleling three buffers provides a faster drive. And we need IC2c to precede the three paralleled buffers in order to cancel the signal inversion from the buffer trio.

Amplifier wanted for water sterilisation

I am working on trying to kill microbes in water through frequency generation. For this purpose I am looking for an amplifier with the following specifications:

Frequency range: 10Hz-500kHz
Input voltage range: 0-10V
Output voltage: 0-100V
Power output: 10W

Linearity is not at all critical. TRIO-Smartcal can offer me such an amplifier but it is a precision instrument with DC coupling and therefore too expensive for my budget. TRIO-Smartcal suggested that I take an ordinary audio amplifier and modify it to extend the frequency range up to 500kHz and suggested that perhaps your organisation could help me with both finding a suitable audio amplifier and modify it. Would this be possible? (J. K., Rarotonga, Cook Islands).

● There is no way a conventional audio amplifier can provide that sort of output at frequencies up to 500kHz. SILICON CHIP has not done any suitable circuit but we would assume that a usable concept would involve a centre-tapped ferrite or sintered core step-up transformer driven by a pair of Mosfets.

OBDII scanner does not work

I recently purchased an OBDII scanner on the internet to help diagnose an engine failure problem that I was experiencing with my car. Unfortunately, it appears that my purchase was a dud as I could not get the device to interface with my Hyundai. Nor could I get it to work with a Nissan or a Daihatsu.

In attempting to get the device to work I ended up doing a lot of research about the ODBII standard for cars and it turns out that it is really just a simple serial communications interface, but running at non-RS232 voltages.

Has SILICON CHIP thought about doing a OBDII diagnostic tool as a project? The basic OBDII functions are really not that complex but are great for the home mechanic to understand what sensor on the engine may have failed. If you are interested I am happy to donate the scanning tool that I had no luck with to you to have a play with.

At the very least the included cable that has the OBDII plug on one end and a D15 plug on the other may be very handy if you wish to experiment in this area. (T. G., Asquith, NSW).

● We published a general article on OBDII plus an OBDII diagnostic tool (project) for connection to a laptop in February 2010.

Whether or not your diagnostic tool works in your car depends on whether the vehicle has OBDII. This only

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Next Month In Silicon Chip: December 2011

The Race For The Square Kilometre Array

Australia and South Africa are the final contenders for a massive radio-astronomy project – the Square Kilometre Array. If Australia gets the nod, about 5500 large dish antennas will be built in the Murchison region of WA. We give the full story.

AM Radio

Ever wanted to build a good old-fashioned AM radio? This simple circuit can be built in two forms: as a portable driving ear buds or in a classic timber cabinet with hand-span tuning dial and loudspeaker.

Home-Theatre Audio Delay

Do you have problems with "lip sync" in your home-theatre system? This is a common problem since many modern flat-panel TVs delay the picture by up to a second. This project allows you to delay the digital audio signal from your DVD player, BluRay player, cable or set-top box to match the picture delay and get them matched up perfectly. Its output can then go to a home-theatre receiver or digital-to-analog converter (DAC). It has both coax and TOSLINK inputs & outputs and the delay is set by remote control.

3-Input Audio Switcher

Need more analog audio inputs for your stereo amplifier or home-theatre set-up? This is a self-contained version of the 3-input selector presented on page 62 of this issue. It is integrated with an infrared remote control or you can just press one of the front-panel buttons to select a program source.

Magnetic Stirrer

We know there are probably not a lot of readers mixing fluids for chemistry or biology work but are you into home brewing? Then this project is for you, to mix and activate your yeast! It is based on a computer fan, a simple speed control and not much else.

Unfortunately, due to space constraints in this issue, the planned article on Measuring Loudspeaker Performance has been held over to the December issue.

Note: the above features are prepared or in preparation for publication and barring unforeseen circumstances, will be in the December issue.

ON-SALE: Wednesday, 30th November 2011

applies to all cars in Australia sold after 2006. Not many cars before this date had OBDII but some did (mainly European, Subaru and some Holden Commodores). Other vehicles had proprietary diagnostics which while they used the OBD connector, did not operate using the OBDII protocol.

So the OBDII scan tool you purchased may work if it is used with an OBDII-compliant vehicle, assuming your Hyundai and both the Nissan and the Daihatsu are not (OBDII-compliant). If this is the case, you may wish to keep the tool for when you update to a later model vehicle.

Electronic rust prevention doesn't work

There seems to be a lot of controversy around electronic rust protection devices, eg, whether they work or not. Would it be possible to do an article on such a device and if feasible, a full project? (B. R., Bundaberg, Qld).

● There isn't any controversy about the subject in the Silicon Chip offices – we cannot see how electronic rust protection can possibly work on cars or vehicles. And nor do we see why any new car purchaser should consider having an electronic rust protection system fitted to their vehicle. After all, most cars these days come with a five or 6-year corrosion guarantee. SC

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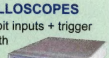

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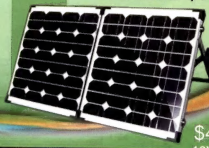
LHP NET AU

the smart choice

NON FOLDING	FOLDING
20W : $59	60W : $199
50W : $150	80W : $299
80W : $250	100W : $350
100W : $300	120W : $399
120W : $350	160W : $499
200W : $599	200W : $599

LCD CHARGE CONTROLLER
30A: $89
50A: $150



240VAC INFOMON PURE SINEWAVE SILENT INVERTER GENERATOR
2KVA: $499
3.5KVA: $799

$49
12V LED LIGHT STRIPS 5M
Cuttable, reusable, weather proof, adhesive back, various colours!

FRIDGE FREEZER
FREE BONUSES: insulation cover, wall charger, & cigarette adaptor. REDUCED!
45L was $1499 NOW $499
80L was $1899 NOW $599

'2R SERIES' LED LIGHT BAR
4x2 (8 LED): $169 10x2 (20 LED): $339
8x2 (16 LED): $288 16x2 (32 LED): $550

LED BAR LAMPS available with a magnetic back! $49

7" DVD/MP3 Player
With USB connectivity to play songs from your iPhone
Plays DVD

$169

INFOMON WIND TURBINE
One of the most reliable & advanced wind turbines for those who want to generate some serious power, sold as a 1kW or 2kW complete kit with a stand and rectifier.
LIMITED STOCK!
1kW: $1899 2kW: $1999

KITCHEN SALE

rangehood
$199

4 burner gas cooktop
$99

ceramic electric cooktop
$299

stainless steel electric fan forced oven
$299

$119 REAR VIEW REVERSING CAMERA COMPLETE SYSTEM

TOOLS CLEARANCE

22CC HEDGE TRIMMER: $149
52CC CHAINSAW: $149
SELF PROPELLED LAWN MOWER: $250
PRESSURE WASHER: $299

REVERSING CAMERA KIT
Includes all connection cables, 7" monitor, remote & IR camera was $189 REDUCED TO (wireless kit: $199) $99

FULL DVR CCTV PACK
4CH: $369 8CH: $799

Infrared! Includes all cables, 4x cameras & DVR kit
Also available in 16 CH: $999
Cameras sold seperately, dome/bracket style only$38

HEATED HYDRO THERAPY SPA
- Computer control touch pad (50+ jets)
- Complete with pumps, filtration system
- Radion heater + recliner head rests
- Available in modern white interior polish
- 100% AUSTRALIAN OWNED company
- 100% AUSTRALIAN APPROVED

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CLEARANCE SALE $3899

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WAS $2599 NOW ONLY $999

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Sale ends 4.00pm saturday

FREE SAUSAGE SIZZLE

THURSDAY 10th – SATURDAY 12th NOVEMBER 2011

DIGITAL ANGLE GAUGE

- Absolute & incremental
- Zero button
- 360° range

SAVE

$59 (M076)

MEASURING KIT 4 PIECE

- 0 - 25mm micrometer
- 150mm / 6" rule
- 150mm / 6" vernier
- 100 x 70mm square

$59 (M012)

HAND TAP & DRILL SET

- HSS taps
- 3 pieces of each size: M3, M4, M5, M6, M8, M10 & M12
- HSS tapping drill size : 2.5, 3.3, 4.2, 5.0, 6.8, 8.5 & 10.2mm
- Including tap wrench in a metal case

SAVE

$59 (TD19)

HSS TAP & DIE SET

- 21 taps (3 per size)
- 3 x 0.5, 4 x 0.7, 5 x 0.8, 6 x 1.0, 6 x 1.25, 10 x 1.5 & 12 x 1.75
- 7 dies x 1" as per sizes above
- Includes button die holder wrench, tap wrench, screw pitch gauge, screw driver

$99 (T013)

HOLE SAW SETS

- Bi-Metal high speed steel hole saw set
- Includes 3/8" & 1/2" arbors, pilot drill & spring

Type	Range	Pcs	
Plumbers	19 - 57mm	6	$44.00 (D103)
Electricians	22 - 64mm	6	$44.00 (D104)
General	19 - 76mm	11	$71.50 (D102)

THREAD REPAIR KIT

- Metric (5,6,8,10,12mm)
- 110 stainless steel threads
- Includes drill & tap for each size

$139 (T100)

PORTABLE VIDEO SCOPE

- 60mm full colour high resolution screen
- 1 metre flexible cable with camera & LED lighting
- 9 volt battery
- Includes 2 metre extension cable, magnetic pick up tool, hook & mirror

SAVE

$165 (M697)

36L AIR COMPRESSOR

- 36 litre tank
- 2.5hp motor
- 134L/min free air delivery
- Direct driven air
- Regulator with twin outlet

SAVE

$209 (C326)

INDUSTRIAL COUNTERSINK SET

- HSS M2 bright finish
- Cross hole type
- Sizes: 2-5, 5-10, 10-18, 15-20mm
- Angle 45°

SAVE

$55 (D1051)

INDUSTRIAL CENTRE DRILL SET

- HSS M2 bright finish
- No. 1, 2, 3, 4, 5

$32.50 (D508)

INDUSTRIAL DRILL SETS

- Metric set 25 piece (D1271)
- Imperial set 29 piece (D1281)
- Precision ground flutes
- HSS M2 bright finish
- 118° split point centre
- 1-13mm range (D1271)
- 1/16 - 1/2" range (D1281)

SAVE

$69 (D1271) $69 (D1281)

INDUSTRIAL COMBINATION DRILL & TAP SET

- HSS M2 bright finish
- Hex shank
- M3, M4, M5, M6, M8, M10mm
- Includes hex snap-on for hand drill

$39 (T0191)

HSS BUTTON DIES

- Precision ground threads

Metric - Button Dies SIZE	DIA.		UNC - Button Dies SIZE	DIA.	
M3 x 0.5mm	1"	$9 (T903)	1/4" x 20TPI	1"	$9 (T940)
M4 x 0.7mm	1"	$9 (T904)	5/16" x 18TPI	1"	$9 (T941)
M5 x 0.8mm	1"	$9 (T905)	3/8" x 16TPI	1 1/2"	$13 (T942)
M6 x 1.0mm	1"	$9 (T906)	1/2" x 13TPI	1 1/2"	$13 (T943)
M8 x 1.25mm	1"	$9 (T908)	5/8" x 11TPI	1 1/2"	$13 (T944)
M10 x 1.5mm	1 1/2"	$13 (T910)	3/4" x 10TPI	1 1/2"	$13 (T945)
M12 x 1.75mm	1 1/2"	$13 (T912)			
M16 x 2.0mm	1 1/2"	$13 (T916)			
M20 x 2.5mm	1 1/2"	$13 (T920)			

HSS TAP SETS

- 1 x taper
- 1 x intermediate
- 1 x plug

Metric Taps - Set of 3 SIZE	
M3 x 0.5mm	$11.00 (T800)
M4 x 0.7mm	$11.00 (T801)
M5 x 0.8mm	$11.00 (T802)
M6 x 1.0mm	$13.00 (T803)
M8 x 1.25mm	$18.50 (T804)
M10 x 1.5mm	$20.00 (T805)
M12 x 1.75mm	$27.00 (T806)
M16 x 2.0mm	$35.00 (T808)
M20 x 2.5mm	$55.00 (T810)

UNC - Set of 3 SIZE	
1/4" x 20TPI	$12.00 (T834)
5/16" x 18TPI	$16.50 (T835)
3/8" x 16TPI	$18.50 (T836)
1/2" x 13TPI	$35.00 (T837)
5/8" x 11TPI	$39.00 (T838)
3/4" x 10TPI	$55.00 (T839)

SAVE

BP-250 BAND SAW

- 375W / 1/3hp, 240V motor
- 245mm throat capacity
- 100mm height capacity
- 090mm dust port
- Includes mitre guide, hp fence & stand

SAVE

$220 (W417)

bts 900x LINISHER

- Tilt finishing table and mitre guide
- Quick release for belt change
- Linishing work area 100 x 280mm
- 150mm disc
- 240V motor

SAVE

$165 (L105)

AL-30 BENCH LATHE

- 0.25kW / 0.33hp, 240V motor
- 300mm between centers
- 90mm centre height
- 20mm spindle bore
- Includes accessories

TOOL SET INCLUDED

$699 (L194)

HM-10 MINI MILL DRILL

- 0.35kW / 0.5hp, 240V motor
- Electronic variable speed (100-2500rpm)
- 2 speed gearbox
- Head tilts ±45°
- Travels: (X) 228mm (Y) 100mm (Z) 190mm

$699 (M150)

Specifications & Prices are subject to change without notification. All prices include GST and valid until 12-11-11

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